GEOLOGICAL SURVEY OF CANADA

REPORTS AND MAPS

OF

INVESTIGATIONS AND SURVEYS.

The publications of the Geological Survey of Canada may be ordered from:—

WM. FOSTER BROWN & CO., Montreal, Que.
C. H. THORBURN, Ottawa, Ont.
WM. TYRRELL & CO., 12 King Street, Toronto.
J. & C. ALLEN & CO., Halifax, N.S.
J. A. McMILLAN, St. John, N.B.
ALEX. TAYLOR, Winnipeg, Man.
THOMSON BROS., Calgary, Alberta.
THOMSON STATIONERY CO., Vancouver, B.C.
T. N. HIBBEN & CO., Victoria, B.C.

ALSO THROUGH

EDWARD STANFORD, 12, 13, 14, Long Acre, London, W.C.
SAMPSON LOW & CO., 188 Fleet Street, London.
F. A. BROCKHAUS, Leipsic.
LEMCKE & BUECHNER, 812 Broadway, New York.
THE SCIENTIFIC PUBLISHING CO., 253 Broadway, New York.

Price, 80 cents.

GEOLOGICAL SURVEY OF CANADA

ROBERT BELL, I.S.O., M.D., Sc.D. (CANTAB.), LL.D., F.R.S.

ANNUAL REPORT

(NEW SERIES)

VOLUME XV

REPORTS A, AA, F AND S.

1902-3

OTTAWA
PRINTED BY S. E. DAWSON, PRINTER TO THE KING'S
MOST EXCELLENT MAJESTY
1906

No. 911

To the Honourable

FRANK OLIVER, M.P.,

Minister of the Interior.

SIR,—I have the honour to submit Volume XV (New Series) of the Reports of the Geological Survey of Canada.

The volume which comprises, with the Index, 1133 pages, is accompanied by several maps and is illustrated by numerous plates.

The several parts composing the volume have been issued previously, as completed, and may be obtained separately.

I have the honour to be, Sir,

Your obedient servant,

ROBERT BELL,

Acting Director.

TABLE OF CONTENTS.

REPORT A.

REPORT AA.

REPORT F.

ILLUSTRATIONS TO REPORT F.

REPORT S.

SECTION OF MINES.

MAPS.

GEOLOGICAL SURVEY OF CANADA
ROBERT BELL, M.D., D.Sc., LL.D., F.R.S.

SUMMARY REPORT

ON THE

OPERATIONS OF THE GEOLOGICAL SURVEY

FOR THE CALENDAR YEAR 1902

BY

THE DIRECTOR

OTTAWA
PRINTED BY S. E. DAWSON, PRINTER TO THE KING'S MOST
EXCELLENT MAJESTY
1903

No. 817.

TABLE OF CONTENTS.

SUMMARY REPORT

ON THE OPERATIONS OF

THE GEOLOGICAL SURVEY OF CANADA

FOR THE CALENDAR YEAR 1902.

The Honourable CLIFFORD SIFTON, M.P.,
Minister of the Interior.

SIR,—In conformity with the Geological Survey Act, 53 Victoria, chapter 11, 1890, I have the honour to submit the following Summary Report of the operations of this department during the calendar year 1902. It contains a statement of the work carried on in all branches of the department, both in the office and museum and in the field. It will be seen that a large amount of original research has been accomplished and that the results of much labour and expenditure of previous years have been made available for the use of the public.

Work devoted to development of mineral resources.

With the exception of the natural history work of the Survey, including palæontology and botany, the whole force of the department has been devoted during the past year to economic geology, with a view to promoting the development of the mineral resources of the Dominion. This applies to the chemical, mineralogical, petrological, topographical, cartological, statistical and educational work, as well as to the field operations.

Prevailing misunderstanding of scope of the Survey.

An erroneous impression prevails among many persons who have never had occasion to inform themselves, as to the nature of the work performed by this department. They imagine that the geologists devote themselves largely to 'theoretical and purely scientific' geology, instead of giving their attention, as they do, entirely to practical work, looking to the development of our various mineral resources.

System followed.

The Geological Survey of Canada was first provided for and organized in 1842, and field-work was begun in 1843, so that we are now in the 61st year of our existence. Our present organization and the system of work followed by the department have been evolved out of an actual experience of sixty years and in addition to this experience, the officers of the Survey have had a full knowledge of the methods

practised by similar Surveys in other countries and have always been ready to consider any suggestion or new departure which might be of advantage in this country. Its present efficient condition is therefore due to the efforts and thoughtful consideration of a very large number of officers of proved ability and devotion, who have successively laboured and passed away during this long period, as well as to the present staff. Every year the Survey is the object of numerous encomiums from practical scientists, both at home and abroad, who observe and appreciate its work.

Efficiency of the Survey recognized abroad.

Among the notices of the operations of the Survey during the last year, the Bulletin of the Geographical Society of Paris for October, 1902, pp. 263-266, in an editorial article on the work of the Geological Survey of Canada in 1901, says: 'During the field season of 1901, not less than thirty-one geological parties organized by the Geological Survey of Canada, were sent out to cover various parts and districts of the Dominion. The operations are always conducted in a practical manner, their object being, not only the scientific study of the fields covered, but also to determine their mineral possibilities from an economic standpoint, and to fix the extent of the formations which may present some interest in this respect. When the operations are conducted over areas which have not previously been delineated, the geological party undertakes concurrently the topography and the mapping of the territory covered.'

Value of maps and reports.

'This work of mapping the geological and topographical features is of great practical utility, inasmuch as it brings out and makes known the great resources of Canada. Such maps and reports are a source of accurate information as to the value of the land, and the probable mineral wealth of the areas explored, affording great help thereby to both the agricultural and mining communities. At a meeting of the British Association for the Advancement of Science, recently held at Belfast, the President, Col. Sir Thomas Holdich, called special attention to the services rendered to colonization by the work of the Geological Survey of Canada. Had such an organization been at work in South Africa, the services which it might have rendered can hardly be over-estimated, and as the eminent British topographer remarks, the results which could have been obtained by such a staff in that territory would have saved many costly experiments and much tentative work. We may add that a systematic method of exploration of our colonies (those of France) conducted on the lines of the Geological Survey of Canada, would have greatly hastened their development and spared many disappointments.

To colonization.

Clearness of maps.

'The maps published by the Geological Survey of Canada are remarkable for their clearness and neatness of execution, and may well

be quoted as models to be followed. For these splendid results, the Director of the Survey, Dr. Robert Bell, deserves great credit and praise. We may mention incidentally that the total annual expenses of the Survey, including administration, exploring expenses and publishing of maps amount to 579,000 francs.

Services of the Director.

Cost.

'The Summary Report of the Geological Survey of Canada for 1901 gives a resumé of the operations of the thirty-one parties sent out during the year.

'In 1901 the Geological Survey published thirty-eight new maps and four profiles. There is moreover the announcement of the very early publication of a general geological map of the Dominion on a scale of about fifty miles to an inch, extending north and east as far as Hudson strait and to the west as far as Great Bear lake.'

Large issue of new maps.

The western half of this map was issued in 1902. The topography of the eastern half is already engraved and the delineation of the geology is in progress.

TOPOGRAPHY.

Canada is indebted mainly to the Geological Survey for its present knowledge of the topography of the Dominion. Few persons have any idea of the vast amount of good topographical work which has been performed, at a comparatively small cost, by the officers of the Department during the sixty years of its existence. Although this has been only incidental to the geological work, the topographical service alone which has been rendered is worth more to the country than the whole cost of the Survey from the beginning.

Topographical surveys made.

Following the original discoverers of the main geographical features of Canada, the officers of the Geological Survey have been the pioneers in the more accurate topographical exploration and survey of the country all the way from the southern parts, northward to the sub-Arctic regions. The accompanying map shows, on a small scale, the areas which have been more or less completely surveyed and mapped and also the routes which have been explored and surveyed in the more northern regions. These reconnaissance surveys extend through all parts of the country to a distance of about a thousand miles northward from the International boundary.

Vast extent of country surveyed.

Previous to the confederation of the first four provinces to form the original Dominion of Canada in 1867 and the subsequent acquisition by the Dominion of the other British possessions in North America, including British Columbia, the territories of the Hudson's Bay Company, the Labrador peninsula and all the islands lying northward of the mainland of North America, the operations of the Geological

Survey were confined to those southern portions which constitute the provinces now called Ontario and Quebec. But since confederation, in addition to the maritime provinces and British Columbia, the attention of the department has been directed to surveying topographically and geologically the vast newly acquired territories above referred to, including those portions of them which have been added to Ontario and Quebec. These great regions were entirely unsurveyed and but partially explored, only the main geographical features being roughly indicated on the sketch-maps. The subdividing of the fertile lands of Manitoba and the North-west Territories for the purpose of settlement was performed by a different department, but the running of the artificial lines required, added comparatively little topography to the map of Canada.

Dominion Lands surveys.

The field-men of the Geological Survey have been the first surveyors of the natural or geographical features of the immense regions referred to which constitute nearly one-half of the continent. In order to map out the rock-formations, the geologists found it necessary to make simultaneously both topographical and geological surveys. From their long experience in these operations they have been able to do this work rapidly and well. Thus an astonishing amount of accurate geographical surveying has been accomplished by a small number of devoted men with very limited means at their disposal.

CHEMICAL AND MINERALOGICAL WORK.

Dr. Hoffmann's work.

As shown by Dr. Hoffmann's report, herewith, this has been of the usual character during the year just closed, and has consisted largely of the examination of specimens of economic minerals which have been sent to the laboratory by miners, prospectors, explorers and landowners in all parts of the Dominion. In each case a written report has been furnished to the inquirer. Systematic chemical examinations have also been made in regard to economic minerals of importance.

Materials most frequently inquired for.

The materials about which inquiry has been most frequently made by letter or by persons calling at the department during the year have been principally the following: asbestus, barytes, bauxite, chromic iron, celestite, cement stone, clays and marls for the manufacture of cement, coal, copper ores, feldspar, fire-clay, graphite, gypsum, iron pyrites, iron ores and iron sands, infusorial earth, kaolin, molybdenite, magnesite, petroleum, platinum, peat, soapstone and zinc ores. Of these again the following were the most frequently inquired for: materials for the manufacture of hydraulic cement, molybdenite, petroleum, iron ores, kaolin and peat.

Peat.

The higher price and threatened scarcity of fuel in the greater part of Canada during the year stimulated popular interest in the peat

resources of the country. The field officers of the department have gathered much valuable information as to the location, extent, depth and quality of peat bogs in the different provinces and the northern districts, and also as to the nature of the various attempts which have been made at different times to manufacture peat fuel.

ROOFING SLATE.

The roofing slates of the Melbourne region in the Eastern Townships do not appear to be excelled in quality by those of any other country in the world. If their merits were better known, both at home and abroad, it is probable that the demand for our slates would be much increased. The following letter from a dealer in slate addressed to Mr. Harrison Watson, Canadian representative at the Imperial Institute, London, contains interesting information on this subject:— Excellent quality of Canadian slate.

LONDON, November 14, 1902.

H. WATSON, Esq.,
Imperial Institute.

DEAR SIR,—Confirming our interview with you, we shall be glad if you will follow up the question of developing the Canadian slate trade.

The present time is very favourable, as the American trade has really stopped, on account of all the slates being required for local demand in America. In consequence of the scarcity of American and Welsh slates, buyers here have gone to France for their requirements. The French slate is not equal to the American in quality, but it is considerably cheaper. The quality of the American is between best French and Welsh and the prices are the same in proportion. The Canadian sample which we inspected at the Institute is a very good slate, and in our opinion equal if not better than the American. The sizes suitable for this market are 24-in. x 12-in., 22-in. x 12-in., 22-in. x 11-in., 20-in. x 12-in., 20-in. x 10-in., 18-in. x 12-in., 18-in. x 10-in., 18-in. x 9-in., 16-in. x 12-in., 16-in. x 10-in., 16-in. x 9-in. and 16-in. x 8-in. The slates you showed us are a little too thick, they should measure 18-in. to 19-in. per 100 slates piled up on the plate. Demand active.

Quarrying in America is carried on at a cost of $1.75 to $2 per square of 100 feet superficial, and the selling price is from $2.40 to $3 per square at quarry. Cost of production.

The slates have to travel, according to the different quarries, from 70 to 200 miles to shipping port. The freight to London from Philadelphia is 13 shillings and five per cent, and the London dock charges are 2s. 6d. per ton if taken by barge from ship. A square of slates weighs about 575 lbs. On the above calculations the selling prices

here are about 12½ to 15 per cent under Welsh prices. The American slate trade with the United Kingdom in 1896 was about 46 million slates, but dropped to half the amount last year, and this year will be considerably less.

Rockland slates.

Slates of the quality of the Rockland slate will always sell, and if prices suit, we are open to make contracts for a large quantity. In our opinion the Canadian slate cleaves well and there is very little waste. The Welsh quarries produce from 100 tons rock, only 10 to 20 tons clear slates; even Lord Penrhyn's quarry, which is considered the best, only produces 25 tons clear slate and 80 tons rubbish.

Proportion of slate to waste.

The American quarries produce from 100 tons rock, about 60 tons good slates and 40 tons waste, which is mostly worked up again into electrical appliances, etc., and we believe you will find the same proportions in Canada. Slate rock is found a few feet from the top, but the deeper one goes the better the slate. An opening can be made to pay at a depth of 30 to 40 feet. There is not much machinery required to open a quarry, and the rock is so abundant in America that the waste caused by breaking the blocks to the required sizes by hand does not matter.

We can deal in slates to the following ports, to most of which there are special steamers running from Montreal: Belfast, Cork, Dublin, Glasgow, Liverpool, Bristol and London.

We shall be glad to give you any further information you may require.

Yours truly,

(Signed) A. HITT,
American Slate Company.

Mineral collections at exhibitions.

The collection of the economic minerals of Canada belonging to the Survey, which had been exhibited in Paris in 1900 and in Glasgow in 1901, was divided into two parts and exhibited during the past summer at the exhibitions held at Wolverhampton and Cork. Pamphlets, giving short descriptions of the mineral resources of Canada, were prepared by the Geological corps and distributed at all the above mentioned exhibitions.

Minerals distributed to schools.

There is an increased demand from the higher educational institutions all over the Dominion for named collections of Canadian minerals and rocks. As shown in Dr. Hoffmann's report, such collections have been supplied as far as possible, subject to certain conditions. I have no doubt these collections have been the means of creating among students and scholars a widespread interest in geology and mineralogy which would not otherwise have existed. The knowledge thus acquired

by so large a number of young men will no doubt have an important effect in leading to the discovery and working of useful minerals in the future.

MINES SECTION.

The report of this section of the department for 1901, was published during the year and amongst other things it gives a large amount of comparative statistics of the mineral production of the country. The complete returns for 1902 are not yet received, but there are indications that there will be a considerable falling off in the output of gold and probably a slight decrease in the total of our mineral products as compared with 1901.

Mr. Ingall, who is in charge of this section, spent the greater part of the summer in making a detailed geological survey of an area measuring about 20 miles square behind the Bruce Mines. He was assisted in this work by Mr. T. Denis, formerly of the same section, and three students. Mr. Ingall's work.

PALÆONTOLOGY.

Dr. Whiteaves has completed Part V., vol. I, of his Mesozoic Fossils and it is now in type (106 pp.) The figures for ten of the twelve plates which are to accompany it have been drawn by Mr. Lawrence M. Lambe, and these will be lithographed in Canada, while the remaining two plates have been already lithographed and printed in England. Dr. Whiteaves' work. A quarto memoir, forming Part 2, volume III of the 'Contributions to Canadian Palæontology' was published during the summer. It is 'on the Vertebrata of the Mid-Cretaceous of the North-west Territory' by Professor Henry Fairfield Osborn and Mr. Lawrence M. Lambe and contains 81 pages of text with numerous figures and 21 fine photogravure plates. Mr. Lambe's reports. A description, with figures, of a new species of Osmundites from the Queen Charlotte Islands, prepared for the Survey by Professor Penhallow, of McGill University and illustrated by several figures, is published in the Proceedings of the Royal Society of Canada for the present yeor. Part 2, volume II, of Professor Samuel H. Scudder's 'Canadian Fossil Insects' was published by the department during the previous year. Dr. Ami's palæontological work has consisted largely of the determination of collections of fossils for the purpose of identifying geological horizons. Dr. Ami's determination of fossils.

BOTANY AND ZOOLOGY.

During the summer, Professor John Macoun visited the Yukon valley and stayed for some weeks at Dawson for the purpose of studying the climate, the indigenous flora and the agricultural possibilities Professor Macoun's report on the Klondike.

of the Klondike district. The results, as set forth in his report, proved to be of much interest and economic importance. Part VII, being the concluding volume of Professor Macoun's catalogue of Canadian plants, was published during the year. It is on the Lichens and Hepaticæ, and contains 318 pages. Part II of the catalogue of Canadian birds by the same author is well advanced and will be issued in 1903. Part III will complete the series. Mr. James M. Macoun, assistant botanist and naturalist, did a successful season's work with the International Boundary Commission in southern British Columbia, and among other results brought home large and interesting collections of plants, birds and mammals. Mr. Lawrence W. Watson, who in 1901, collected plants and studied the flora of Prince Edward Island for the Survey, has completed his list of the plants of that province and it is intended to publish it as soon as possible.

On lichens, birds, etc.

Mr. J. M. Macoun.

Mr. Watson's flora of P.E.I.

FLORA OF HUDSON BAY.

Flora of Hudson bay.

A memoir on the flora of Hudson bay, based on the plants collected around that sea at various times and places by the officers of the Survey, has been prepared by Professor John Macoun, Mr. J.M. Macoun and Dr. Theodore Holm of Washington. These collections were found to contain ten new species of flowering plants, which have been described jointly by the three botanists just named. Dr. Holm has made drawings of each species to illustrate the descriptions and these will be reproduced in the form of ten plates to accompany the memoir. The work will be issued as one of the special publications of the Survey.

Dr. Theodore Holm's drawings.

MAPS.

The preparation and engraving of maps, resulting from the field-work of the officers of the Survey, has been pushed forward with great energy under the direction of Mr. C. O. Senécal, the geographer and chief draftsman of the department. This officer's report contains full particulars of the work accomplished and a statement of the maps published during the year.

Work of Mr. C. O. Senécal.

OTHER PUBLICATIONS.

List of publications in 1902.

The following reports and special works have also been published by the Survey in 1902:—

Summary Report of the Geological Survey for the calendar year 1901, pp. 269, with 3 sections, 4 plates and 10 maps.

Part A, vol. XIV., with 10 maps, plates, and sections, by the geological corps.

Report on the surface geology shown on the Fredericton and Andover quarter-sheet maps, New Brunswick, Part M, vol. XII., pp. 41, by Dr. Robert Chalmers.

Notes on certain Archæan Rocks of the Ottawa Valley, Part O, vol. XII., pp. 84, by Prof. Osann.

Report on an Exploration of the east coast of Hudson Bay, Part D, vol. XIII., pp. 84, with maps, by Mr. A. P. Low.

Report on Explorations in the north-eastern portion of the District of Saskatchewan, &c. Part F, vol. XIII., pp. 48, by J. B. Tyrrell.

Report on Geological Explorations in Athabasca, Saskatchewan and Keewatin Districts, &c. Part FF, vol. XIII., pp. 44, by Mr. D. B. Dowling. The Grass River map-sheet accompanies Reports F and FF.

Report on the Nottaway River basin. Part K, vol. XIII., pp. 11, with a geological map, by Dr. Robert Bell.

Report on the Geology and Petrography of Shefford Mountain, Quebec, by Principal J. A. Dresser. Part L, vol. XIII., pp. 35.

Report upon the Carboniferous System of New Brunswick, &c. Part M, vol. XIII., pp. 38, by Professor L. W. Bailey.

Report upon the Carboniferous System of New Brunswick, &c. Part MM, vol. XIII., pp. 38, by H. S. Poole, Esq.

Section of Mines Annual Report for 1900. Part S, vol. XIII., pp. 160, by Mr. E. D. Ingall and Mr. McLeish.

Annual Report, vol. XII. (new series), 1899, English edition, pp. 972, with 8 maps.

Annual Report, vol. XI. (new series), French edition, pp. 934.

Catalogue of Canadian Plants, Part VII., Lichens and Hepaticæ, pp. 318, by Prof. John Macoun.

Contributions to Canadian Palæontology, vol. III. (quarto). Part II., "On Vertebrata of the Mid-Cretaceous of the North-west Territory," by Professor Henry Fairfield Osborn and Mr. Lawrence M. Lambe, 81 pages, illustrated with numerous text-figures and twenty-one photogravure plates, viz.:—

1. Distinctive characters of the Mid-Cretaceous Fauna, by Prof. Henry Fairfield Osborn.
2. New genera and species from the Belly River series (Mid-Cretaceous), by Lawrence M. Lambe.

Field Work.

As in the previous year, as many field parties as our funds would permit of were sent out, including some under the control of geologists not connected with the Survey, but employed for the season only. Twenty-two parties or geologists, working independently of each other, were engaged in field operations. In some cases where the assistants were able to do good topographical or geological work, the party was divided after reaching its ground and the two sections worked separately for the greater part of the season, so that the total number of field officers operating independently may be said to have been twenty-seven. Most of these officers remained out during the whole season, but a few of them for a shorter period.

Twenty-seven field officers at work.

Following the plan adopted last year, the report of each field and staff officer is given separately and as the field operations and other work of the department are thus fully explained, it is only necessary for me here to give a brief outline of the former, enumerating the regions covered in their order from north-west to south-east, as in last year's Summary Report.

R. G. McConnell's survey of Macmillan river.

The most northerly expedition was that of Mr. R. G. McConnell, who, with Mr. Joseph Keele as assistant, made an instrumental topographical survey and a geological reconnaissance of the Macmillan river, a stream nearly as large as the Ottawa, which falls into the Pelly from the east, a short distance above the point where the latter joins the Lewes to form the Yukon. On reaching the forks of the Macmillan the instrumental survey was discontinued and Mr. McConnell explored the northern branch, while Mr. Keele traced the southern. In addition to the work done along the main river and its branches, the hills and mountains on either side were ascended at frequent intervals for the purpose of examining the rocks. It was found that from the mouth of the river to the highest points reached, the main stream and both its branches flowed over crystalline rocks, mostly altered sediments. Samples were collectod from a number of quartz veins and it was hoped that some of these would be found to contain gold, but on assay in the laboratory of the Survey, none was detected. The results of the above work are, therefore, valuable principally on account of the new topography and geology acquired, as well as the general information in regard to the nature of the country through which the Macmillan river flows.

Barren quartz veins.

Vancouver island.

Up to the past season, no examination had been made by the Geological Survey of the outer or south-western coast of Vancouver island, except for a few miles at the north-western extremity. As it had become important to obtain information in regard to the rocks and pos-

sible economic minerals of this coast, it was decided to send a party to work there. For this service, Mr. Arthur Webster, a former member of the staff and Professor Ernest Haycock of Acadia College, Wolfville, Nova Scotia, were selected. The coast, being bold and exposed to the sweep of the Pacific ocean, was found difficult to examine by means of a small boat. Still, these gentlemen succeeded in exploring it from the Straits of Fuca to within a short distance of the north-western extremity of the island. From their reports it will be seen that along the whole coast, granites and basic eruptives are largely developed, while unaltered sedimentary rocks are frequently found resting upon them. Ores of copper occur in several places and in some instances they appear to exist in promising quantities.

Survey by Webster and Haycock.

Ores of copper.

Dr. R. A. Daly continued the work begun the previous year along the International boundary between British Columbia and the State of Washington and to a distance of ten miles to tbe northward of it. The rocks examined in the field consist mostly of altered sediments and eruptives. Dr. Daly is now making a petrographic study of these rocks and of the structural and physiographic geology of the ground he worked over.

Dr. Daly's work.

Mr. James M. Macoun was employed as naturalist near the International boundary in the same region as Dr. Daly. Besides studying the fauna and flora on the ground, he made valuable collections of mammals, birds and plants.

J. M. Macoun, Naturalist to Boundary Commission.

Mr. R. W. Brock and Mr. W. H. Boyd investigated a mining area of about fifteen miles square around the town of Greenwood, in the boundary district in British Columbia. The latter attended to the topographical work, while the former traced out the limits of the various rock-masses and studied their petrography. A map of this area is being prepared to show the geology and the hill-features by means of contour lines.

Greenwood mining area.

In the region between the Slave and Peace rivers of the great Mackenzie basin, Mr. C. Camsell worked in the district to the westward of Fort Smith, which is situated about midway from Athabasca lake to Great Slave lake. He made a track-survey of a canoe-route between the Slave and Peace rivers, but his principal work consisted of investigations as to the occurrence of salt and gypsum in the Devonian rocks of this country, He went by the Athabasca river and returned by way of the Peace.

Explorations in the Mackenzie basin.

Salt and gypsum.

Among the Rocky mountains and along their eastern flanks, coal of good quality occurs in great quantities in Cretaceous rocks for a long distance northward from the International boundary. In the Crowsnest Pass coal-field, which is being developed on the line of the Canadian

Crows-nest coal field.

Section.

Pacific railway, in a total section of 4,736 feet there are 22 seams with an aggregate thickness of 216 feet of coal, of which over 100 feet are workable under present conditions. Coal basins run with some interruptions for hundreds of miles northward from the Crows-nest Pass. In the foot-hills on the east side of the Rocky mountains, the coal seams are repeated and they are traversed by the southern branch of the Canadian Pacific railway in the district of Alberta. During the past season the geology of a considerable area of the coal belt in the vicinity of Blairmore was investigated by Mr. W. W. Leach. A map of this area by Mr. Leach accompanies his report in the present volume, in which much valuable information is given as to these coal-bearing rocks. Coal crops out in many places and is probably widely distributed in our prairie region east of the Rocky mountains. This abundance of good fuel will add greatly to the value of these agricultural lands.

W. W. Leach's report and map.

Mr. Dowling's work in Manitoba and Assiniboia.

Lignite of Tertiary age is found in seams of moderate thickness in the Turtle mountain region of southern Manitoba and in the Souris river country, lying to the westward, in Assiniboia. These lignites were investigated last season by Mr. D. B. Dowling and found to be of more economic value than had been supposed. Mr. Dowling also made some investigations in connection with the occurrence of gypsum between Lakes Winnipeg and Manitoba.

Gypsum.

Albany and Severn rivers.

Between the head-waters of the Albany and the Severn rivers, a large region remained unexplored both geographically and geologically. During the past season part of this was examined by Dr. Alfred W. G. Wilson, assisted by Mr. Frank Johnson. It proved to be a level country with here and there a low ridge or knob of Laurentian gneiss. Two narrow belts of Huronian schists were found.

Explorations on James bay by W. J. Wilson and O. O'Sullivan.

On the west side of James bay, three good-sized rivers remained to be surveyed. One of these, the Kapiskau, falls into the bay between the Attawapiskat and the Albany, while the two others lie between the Albany and the Moose. These were surveyed, both topographically and geologically by Mr. W. J. Wilson and Mr. Owen O'Sullivan. On all these streams they met with only the same nearly horizontal Devonian rocks which had been found by myself on all the other principal rivers to the west and south of James bay, and these rocks were also overlaid everywhere by a thick mantle of stiff clayey till, like that along the streams which had been previously surveyed. The economic minerals of this region consist of gypsum and clay-ironstone in the Devonian strata, while workable beds of lignite, apparently of considerable extent, occur in the drift along the Moose river and some of its northern branches.

In 1901 it was decided to complete two of our regular topographical and geological map-sheets, each covering 72 miles from east to west by 48 miles from north to south, in order to show the whole Lake Nipigon region, the lake itself occupying the central portion of the united sheet. The field-work necessary to complete the west half of the southern sheet was done by Dr. Alfred W. G. Wilson in 1901, and that required in the east half of this sheet by Dr. W. A. Parks of Toronto University, the same season. In 1902 the latter worked out the requisite details in the east half of the northern sheet, while Mr. William McInnes finished the west half of the same sheet. The resulting topographical and geological map of the whole country around Lake Nipigon, measuring 72 miles from east to west and 96 miles from north to south, is well advanced. It is a valuable addition to the geography of Northern Ontario and the distribution of the different rock-formations is such that it shows a considerable diversity of geological colouring.

Lake Nipigon maps.

Work done by Drs. Wilson and Parks.

By William McInnes.

Discoveries of copper have been made in the last few years in the country behind the Bruce Mines on the north shore of Lake Huron, and it was considered desirable to make a more detailed geological survey of this district. Accordingly, Mr. E. D. Ingall, Chief of the Mines section of the Survey, was instructed to undertake this work. He was assisted by Mr. T. Denis, also of the geological corps, and a survey was made of a tract embracing about twenty miles square in the country immediately north of the Bruce Mines, most of which is now settled. Another season will be required to trace out accurately the remaining geological lines of this area. We shall then have a map showing better than does the existing one, the boundaries of the rock-formations in this interesting part of the original Huronian area.

Bruce copper mines.

Surveys by E. D. Ingall and T. Denis.

Dr. A. E. Barlow was instructed to continue his researches among the nickel-bearing rocks of the Sudbury district. These have been found to belong to three belts—a northern, a middle and a southern. The rocks of this district have proved to be of considerable lithological interest. The various granites and greenstones have been differentiated and the relations of the nickel deposits to them determined to a considerable extent.

Nickel ores of Sudbury.

Professor F. D. Adams and Dr. A. E. Barlow had been engaged for several seasons in working out in detail the geographical distribution of the subdivisions of the Laurentian rocks within the limits of one of our regular map-sheets, covering an area of 72 miles from east to west, by 48 miles from north to south. This map has been called the 'Haliburton sheet.' Dr. Adams visited this region during the past summer in order to ascertain some details required to finish the mapping of certain geological lines. The engraving of this map in black has been

Work by Professor Adams and Dr. Barlow for the Haliburton sheet.

completed for more than a year and now that the geology has been laid down upon it, only the latter remains to be engraved and printed. In the region covered by the Haliburton map, there is an unusual variety of Laurentian rocks, and these have now been mapped with so much care that this will be the most complete representation of an Archæan area yet produced in America. A map of a portion of the same area, with some additions, has been completed on a larger scale and will be published about the same time.

Surveys for Kingston map by Dr. R. W. Ells and Mr. Hugh Ells.

In the country around Kingston, Ontario, Dr. R. W. Ells and Mr. Hugh Ells have nearly finished the field-work necessary for completing the 'Kingston sheet,' the area covered measuring 72 by 48 miles. The irregular contact of the Ordovician with the Archæan rocks runs through the sheet and requires much detailed field-work in order to locate all its sinuosities.

Dr. Chalmers' investigations in surface geology.

Dr. Robert Chalmers, whose time is devoted to surface geology, wells and artesian borings, worked again during the past season in the inter-lake peninsula of Ontario. In addition to investigations connected with underground waters, petroleum, gas and salt, he examined the clay deposits from both a geological and economical point of view. He also traced carefully and mapped out some of the ancient beaches, so well developed in that region, from Lake Huron eastward to the vicinity of the outlet of Lake Ontario. A map showing a portion of the latter work accompanies his report.

Copper mines of the Eastern Townships.

In the copper region of the Eastern Townships (which lie between the St. Lawrence river, on the one hand, and the states of Maine and New Hampshire on the other) it was believed that by studying petrologically the rocks associated with the copper ores, we might be able, by combining the results with the stratigraphy, to recognize and limit more accurately the copper-bearing belts. The field-work and the microscopic study connected with this investigation were undertaken by Principal Dresser of St. Francis College, Richmond. He has found that the copper ores are confined mainly to three principal belts, consisting mostly of basic eruptives. The results of his work promise to lead the way to discoveries of economic value.

Discoveries by Principal Dresser.

Dr. Ells investigation of the petroleum of Gaspé.

Dr. Ells was instructed to investigate the petroleum problem in the peninsula of Gaspé, which forms the extremity of the land on the south side of the lower St. Lawrence. For more than half a century the existence of petroleum in this region has been known to the Geological Survey. For a number of years back, the district has been exploited by companies formed in Europe and many deep wells have been bored. Until last year, it was difficult to secure much reliable information as to the results that were being obtained. But all the

obstacles having been removed, Dr. Ells was able to collect, during the past season, full and accurate information as to the outcome of the operations of all the different companies. This is a matter of great importance, and, owing to the facilities afforded Dr. Ells for his investigations in all parts of the reported oil region, he has been enabled to prepare an interesting report on the whole subject.

Prospect of finding coal in Prince Edward Island.

The same gentleman also spent a part of the season in investigating questions as to the possibility of finding coal within workable depths in Prince Edward Island. As a result, boring operations will probably be commenced next year by the local government in the hope of finding coal seams within reach under the Upper or Permo-Carboniferous rocks of the island.

Surveys in New Brunswick by Professor Bailey and Mr. Johnston.

The northern interior of New Brunswick, or the region around the head-waters of the Tobique and Nepisiguit rivers, was further explored by Professor L. W. Bailey of the University of New Brunswick, who has worked for the Survey for many years. Dr. Bailey was assisted by Mr. Robert Johnston of the regular staff. Their exploration shows that further investigations will be required before the geology of that region can be satisfactorily laid down upon a map.

By Mr. H. S. Poole in New Brunswick and Nova Scotia.

Mr. H. S. Poole, who had been engaged during the season of 1901, in going over the Carboniferous rocks of New Brunswick in the hope that he might discover a possibility of the occurrence of workable coal seams, was requested to examine the region lying around Chignecto bay, so as to confirm or correct our previous mapping of the rock-formations in that neighbourhood and to establish more clearly the relations of the Carboniferous rocks of New Brunswick and Nova Scotia.

Gold districts of Nova Scotia mapped by Mr. Faribault.

Mr. E. R. Faribault has been engaged for a number of years in making topographical and geological surveys of the gold districts of Nova Scotia and mapping each one separately. He spent a part of the year in preparing several of his plans of these districts for publication and the remainder of his time in the field. He was again assisted by Mr. A. Cameron and Mr. J. M. Cruickshank, who have been engaged on this kind of work with Mr. Faribault for a number of years.

Coal mines of Nova Scotia.

Mr. Hugh Fletcher was again engaged in Nova Scotia, principally on work connected with the coal-bearing rocks. On account of his familiarity, from past experience, with the geology of the various coal fields of Nova Scotia, which are now undergoing active exploration or development, his services were requested in several places where new work was in progress, in order to give advice as to the best course to pursue by the operators. The latter part of the season was devoted to a continuation of his investigations in the Springhill coal-field. He

Springhill.

was assisted by Mr. McLeod and Mr. Allan McKinnon. The various kinds of work in which he and his assistants were occupied are described in his report in this volume.

Inspections by Dr. Bell.

My own field-work consisted of visits of inspection to the Michipicoten district, Lake Superior, the region behind Bruce Mines, Lake Huron, where Mr. Ingall and Mr. Denis were at work, the county of Frontenac, the copper discoveries near Matane on the south side of the St. Lawrence about 220 miles below Quebec, and to some of the gold and coal districts of Nova Scotia, including Cape Breton.

Exploration of Albany district by Jabez Williams.

I should here mention that Mr. Jabez Williams, an officer of the Hudson's Bay Company, now resident at Osnaburgh House, who has a good knowledge of prospecting, has sent me a report on an exploration which he made the previous year of a tract of country lying north of the section of the Albany river between Eabamet and Martin falls, of which we had previously but little geological knowledge. Mr. Williams' report was accompanied by a collection of specimens of the rocks which he met with. The report and specimens will aid us in mapping the geology of the Albany district, and the thanks of the department are due to Mr. Williams for this valuable contribution.

Contributions by A. P. Low.

We are also indebted to Mr. A. P. Low, (for many years a regular member of the staff of the Survey) for several original maps and a detailed report on the geology of the Hopewell group of islands and a number of the islands of the Nastapoka group, on the east side of Hudson bay. Mr. Low did the field-work in 1901 for the Dominion Development Company of Philadelphia, which kindly consented to allow him to present these valuable results to the department for publication. The maps have been used in the compilation of the sheet that is being engraved to accompany Mr. Low's report for 1900, which is to form part of volume XIII., (N.S.,) of our regular annual reports.

Supplement to J. B. Tyrrell's work in the Yukon district.

In 1896 Mr. J. B. Tyrrell, before severing his connection with the Survey, made an examination of the Dalton trail from the head of the Lynn canal to the Lewes river in the Yukon district, but he deferred sending in his report on this work until he could obtain petrographical descriptions of the series of rock-specimens which he had collected while engaged upon it. Thin slices of these specimens have been made in Germany and with the aid of these, Dr. Barlow is drawing up a description of this series of rocks, to be forwarded to Mr. Tyrrell, who is now residing at Dawson, Yukon district.

Report on E. Coste's map of Madoc and Marmora.

In 1883, Mr. Eugene Coste made a geological examination of the townships of Madoc and Marmora for the Survey, and the map to illustrate his report was engraved and printed in colours the following year. It is now expected that Mr. Coste will furnish a report on the above work to be issued along with this map.

Geological Nomenclature and the Colouring of Geological Maps.

The want of a uniform system of geological nomenclature and map-colouring, applicable to the whole of North America, has long been felt. This has been the case more especially in late years when it has become necessary to colour geological maps of large areas, so that they may be in harmony on both sides of the International boundary. There is likewise a lack of uniformity as to the terms which are employed to distinguish the various geological periods. The absence of a general agreement in these matters was also felt many years ago by the geologists of all the countries of Europe and it was from this circumstance that the International Geological Congress arose in 1876.

Uniform system of Geological nomenclature necessary.

In 1881, the late Dr. Selwyn proposed a scheme of geological nomenclature and of colouring of geological maps, in order to secure uniformity in the reports and maps of the Canadian Survey, but this was not adopted elsewhere. (See Report of Progress of the Geological Survey of Canada for 1880–82, pp. 47 to 51).

In 1901, the geological and biological section of our Royal Society (Section IV.) seeing the necessity of moving in this important matter, passed a resolution, requesting the writer to convene a committee of geologists of his own choosing, to consider all matters connected with the nomenclature of geological divisions in Canada. The following report explains what was done in the matter.

Report of the Committee of the Royal Society on the Nomenclature of Geological Formations in Canada.

Ottawa, 22nd May, 1902.

The Secretary,
Section IV, Royal Society of Canada,
Toronto.

Sir,—At the last meeting of the Royal Society, I was requested by Section IV to select a committee of geologists, of which I was to act as convener, to take into consideration The Nomenclature of Geological Formations in Canada.

Action taken at Royal Society meeting.

In the beginning of May, a committee for this purpose was named and a meeting called for the 10th, of the month. The following geologists were invited and all accepted :—Dr. J. F. Whiteaves, Dr. R. W. Ells, Mr. Hugh Fletcher, Mr. R. G. McConnell, Dr. Robert Chalmers, all of the Geological Survey, Professor W. G. Miller, Provincial Geologist, Toronto, Professor F. D. Adams, McGill University, Montreal,

Mr. B. E. Walker, Toronto, Dr. George F. Matthew, St. John, N.B., Professor H. S. Poole, Dalhousie University, Halifax.

The meeting called for the 10th of May, was held in my office in Ottawa and was attended by all the members, except the three last mentioned. Mr. Walker was about to sail for Europe and Dr. Matthew and Professor Poole were unable to come so far.

Opinion of committee.

After considerable discussion, it was the general opinion of the committee that there is need for a uniform and better understanding as to the significance, not only of the proper names in use (for the divisions of the geological scale), but as to the relative comprehensiveness and classification of geological divisions themselves.

The unnecessary multiplication of so-called formational names was deprecated and it was felt that it would be advantageous if some method could be adopted by geologists, which would allow of a general consideration or discussion of proposed new names for divisions of rocks before they were recommended for adoption.

Dr. J. F. Whiteaves, Mr. H. Fletcher, Mr. McConnell and Dr. Adams were appointed a sub-committee to consider the names of the various divisions of the whole sedimentary series in Canada, from the Archæan up to the Pleistocene.

Co-operation of United States and continental geologists desirable.

It was considered desirable that the present committee should be authorized by section IV to enter into correspondence with the Geological Survey of the United States or any other body of geologists on the continent, with a view to securing, as far as possible, greater harmony and uniformity in the nomenclature of geological divisions, subdivisions and masses of rocks of all ages throughout North America.

The committees then adjourned with the intention of meeting, if possible, during the session of the Royal Society in Toronto.

Respectfully submitted,

(Signed) ROBERT BELL,
Convener.

The foregoing report was read at the Toronto meeting, at which it was adopted and the committee continued, with power to add to its numbers.

Conference with American geologists in Washington.

Later in the year, after some correspondence on this subject with Professor Charles D. Walcott, Director of the Geological Survey of the United States, and Professor C. R. Van Hise of the same Survey,

who has taken a great interest in the matter, it was arranged that the writer should meet and confer with these gentlemen in Washington. Professor Walcott named Dr. C. W. Hayes and Professor Van Hise, to meet Dr. F. D. Adams and myself as a joint committee to discuss the whole matter and make arrangements for carrying out the objects in view. The results are given in the following document:—

Minutes of meeting of joint committee on nomenclature, consisting of Drs. Robert Bell and Frank D. Adams, representing the Canadian Geological Survey, and C. W. Hayes and C. R. Van Hise, represent ing the U. S. Geological Survey, held at Washington, D.C., January 2, 1903.

C. W. Hayes in the chair.

Present also Messrs. Bell, Adams and Van Hise.

1. It was agreed that the committee, as constituted by mutual consent between the Directors of the two Surveys concerned, should form a permanent committee and should appoint sub-committees for the consideration of questions of nomenclature in various regions along the United States-Canadian Boundary. It was agreed that the nomenclature of these regions should be taken up as rapidly as the necessary information for a satisfactory adjustment should become available, and that during the coming year the questions of nomenclature in the Adirondack and Lake Superior regions should be considered.

Sub-committee selected.

2. It was agreed to submit questions of nomenclature in the Adirondack region to a sub-committee, consisting of Messrs. Van Hise and Adams, who were instructed to confer and report their recommendations to the full committee.

3. It was agreed that questions of nomenclature in the Lake Superior region should be considered by a joint sub-committee, consisting of Prof. C. R. Van Hise, Mr. C. K. Leith, and, by invitation, Dr. A. C. Lane, State Geologist of Michigan, on the part of the United States, and Acting Director Robert Bell, Prof. Frank D. Adams, and, by invitation, Mr. W. G. Miller, Geologist for the Province of Ontario, on the part of Canada.

4. It was agreed that this sub-committee should make arrangements by correspondence between Messrs. Van Hise and Bell, Chairmen of the sub-committees, for a joint field conference during the coming field season.

5. It was agreed that the permanent joint committee should hold a meeting in connection with the next winter meeting of the Geological Society of America, and, if necessary, other meetings at the call of the Chairman.

(Signed) C. W. HAYES,
Chairman.

Shortly after the above meeting had been held, it was found that some of the American geologists who had been designated would not be able to proceed to carry out the necessary joint field-work this season, and it was, therefore, agreed to postpone active operations till next year. Meantime, it is expected that some progress towards the ends desired, will be made by a more careful study of the reports which have been written as to various controverted points and by conferences in regard to them. It is confidently expected that the active combined field-work of the committee will be commenced in the spring of 1904.

OFFICERS REPORTS.

The Macmillan River, Yukon District.

Mr. R. G. McConnell.

Work by R. G. McConnell and Joseph Keele.

The work during the season of 1902, consisted in making an examination of the Macmillan river, one of the principal feeders of the Pelly. I left Ottawa on the 7th of June, accompanied by Mr. Joseph Keele, and reached Whitehorse, where we outfitted, on the 17th of June, and Fort Selkirk at the mouth of the Pelly, on the 22nd. Two days afterwards we proceeded up the Pelly river, carrying our summer supplies in two Peterborough canoes which we had brought with us from Ontario.

The party consisted of Mr. Keele, who acted as topographer and assistant geologist, the writer, and two canoemen from Sault Ste. Marie. We were delayed on the Pelly by the flooded condition of the river, the highest rise of the season occurring on June 29, and did not reach the mouth of the Macmillan until July 5.

Survey of Macmillan river.

The early part of the season was occupied in making a traverse by micrometer up the Macmillan to the forks, a distance of about 150 miles. The micrometer traverse was afterwards continued by Mr. Keele up the South fork for a further distance of fifty miles. The North fork proved to be an exceedingly rapid stream, very difficult to ascend, and as time was limited and it was important to explore both branches, Mr. Keele was directed to survey as much of the South fork and its tributaries as possible, while the writer continued on up the North fork. This was ascended to a point a few miles above Cache creek, and then the latter stream was followed to its head. We had been informed that it headed with Peel river, but this proved to be incorrect. The valley occupied by Cache creek connects the Macmillan with the South fork of the Stewart, and from the top of a mountain at its head, which was ascended, the valley of the Stewart could be traced at least thirty miles in a north-easterly direction. The head of

Cache creek, the farthest point gained, was reached on August 12, and on the 13th we commenced the return journey. A number of mountains had been selected for climbing on the way up, and stoppages of from one to three days were made at those points on the way down. A micrometer traverse was also made of the Pelly from its junction with the Macmillan to Fort Selkirk at its mouth.

General Description of Macmillan River.

Length of North and South forks.

The Macmillan river has a total length of about 285 miles. It divides at 150 miles above its mouth into two nearly equal branches, known as the North and South forks. The North fork carries the most water, and has a length of about 135 miles. The South fork is probably of nearly equal length.

Cut banks of plastic clay.

The main river, in its lower reaches, is a winding stream varying in width from 300 to 500 feet. The current is sluggish, seldom exceeding, in the first fifty miles, a rate of three miles an hour. The valley has a width of from one to five miles or more and is covered with a heavy deposit of clays, silts, sands, gravels and boulder clay. The river has cut a great trench in these deposits usually about 200 feet in depth, and from one mile to two miles in width, and now winds from side to side of this depression, occasionally cutting into and destroying portions of the bordering banks. In the lower portion of the river the cut banks consist largely of a bluish plastic clay, and at several points great masses of this material have slidden forward and in some instances formed barriers extending nearly across the river. The drift plain bordering the river banks is bounded on both sides by ranges and groups of hills and mountains, rising from 2,000 feet to nearly 5,000 feet above the level of the valley.

Navigable by small steamers.

The easy current characteristic of the lower portion of the Macmillan is interrupted about fifty miles above its mouth, by a stretch of comparatively rapid water five or six miles in length, above which the current is again generally slack for a further distance of fifty miles, although a few riffles occur. In the upper fifty miles, the current becomes much swifter, flowing at a rate of from three to five miles an hour. The swiftest stretches occur at places where the stream has recently broken through the necks of ox-bow bends, and so shortened its course. The greater portion of the river is easily navigable, except at low water, by small steamers.

The principal difficulty occurs at Porphyry bluff. The river at this point runs swiftly around a number of sharp bends and the channel is filled with snags. The latter could easily be removed if necessary. The grade of the Macmillan was estimated at from one to two feet per

mile in the lower portion of the river and from two to four feet in the upper portion. The average grade throughout, probably amounts to about three feet to the mile and the total fall from The Forks to the Pelly is estimated at 450 feet.

Principal strems entering Macmillan river.

The principal feeders of the Macmillan below The Forks are Kalzas river, Moose river and Russell creek. The streams are all northern tributaries, no important feeders entering the river from the south. Kalzas river, which joins the Macmillan twenty-seven miles above its mouth, is a large rapid stream about sixty feet in width. It forks a short distance above its mouth, the principal branch occupying a wide terraced valley, which extends in a north-easterly direction for a distance of about forty miles. The north-westerly branch empties Kalzas lake, a sheet of water about six miles in length, lying behind the Macmillan mountains. This branch follows part of an old valley, which has been traced from the Pelly, in a north-westerly direction to the Klondike and beyond. This valley is occupied in different parts of its course by a portion of the Pelly, a branch of Kalzas river, Crooked creek, a portion of the Stewart river, Clear creek, Flat creek, and the lower part of the North fork of the Klondike river. This ancient drainage channel is an important topographical feature of the country, and may prove to be of economic value, as gold may be concentrated in portions of its course. It runs in a north-westerly direction, crossing the present main drainage channels diagonally, and has a width of from two to ten miles or more. In the glaciated area, it is bordered by wide terraces built up of silts, sands, gravels and boulder clay, and in the unglaciated area, north of the Stewart, it is filled to a depth of at least 600 feet with sand and gravel.

Ancien drainage channel.

Moose river.

Moose river, which enters the Macmillan about midway to the Forks, also occupies an old valley which extends in a north-easterly direction to the South fork of the Stewart, but has not been traced beyond. Moose river is a winding stream about 50 feet in width having a length measured along the valley of about eighteen miles, but following the windings of the stream it is fully twice this distance. It is the outlet of Moose lake, a body of water about eight miles in length occupying a depression in the floor of the old valley.

Russell creek.

Russell creek (Red Slate creek) joins the Macmillan about four miles below the Forks and is important as being the only tributary, so far, on which coarse gold has been found. It heads in a small lake 12 miles north of the Macmillan, and has a total fall of 1,400 feet. It is a rapid stream about 40 feet in width and is fed by a number of impetuous torrents descending from the mountains bordering its valley. The valley of Russell creek is from one to three miles in width and extends through to the Stewart drainage system.

Recent elevation in this valley is shown by the fact that the present stream has cut in places a canyon in the bottom of the old channel.

Mountainous character of country.

Topography—The general character of the country in the vicinity of the Macmillan is mountainous, although the ranges as a rule are isolated by wide valleys and depressions. Below Kalzas river the Macmillan is bordered on the north by the Macmillan mountains; a long ridge with fairly even slopes except near the centre, where it rises about 1,000 feet above the tree line and is broken into a number of rocky peaks, the highest of which has an elevation of about 3,800 feet above the level of the river or 5,600 above the sea. Opposite the Macmillan mountains the country between the Macmillan and the Pelly is occupied by a high plateau-like mass with smooth outlines, the summit of which rises just above the tree line to an elevation of about 2,700 feet over the valley. East of this plateau is a wide depression, extending east to Dromedary mountain and south to the Pelly. This depression is faced on the north of the Macmillan by Kalzas mountain and the range connected with it. Kalzas mountain rises 4,300 feet above the valley and is the highest peak along the main Macmillan river. Northeast from it, at a distance of ten miles, is Clarks peak, a conspicuous conical mountain, visible from almost every elevation climbed to, along the river.

The region north of the Macmillan, between the valley of Moose river and Russell creek, is occupied by a high broken plateau, deeply trenched by numerous streams flowing into the surrounding valleys. South of the Macmillan the country bordering on the valley, with the exception of a couple of relatively unimportant depressions, is rough and mountainous from Dromedary mountain east to the Forks. The mountains, mountain groups, and broken uplands along the Macmillan valley have a common origin and may be briefly described as representing surviving fragments of an extensive highland, the major portion of which has been destroyed by sub-aerial denudation and erosion.

The North Fork of the Macmillan.

Description of North fork of Macmillan river.

The Macmillan, a few miles above Russell creek, separates into two branches known as the North and South forks. The two branches are nearly equal in size, but the former carries a much larger volume of water. The North fork, although it continues for some miles in the same direction as the main Macmillan and occupies a similar wide flat bottomed valley, differs entirely in character.

It is an exceedingly rapid stream and bears more resemblance to a mountain torrent than to an ordinary river. Between the Forks and Cache creek, a distance of 45 miles, measured along the valley, and

about 70 miles following the windings of the river, the former has a fall of about 18 feet to the mile and the river of about 12 feet to the mile. The current is uniformly swift throughout, running at the rate of from five to eight miles an hour. The channel in places is filled with boulders, and strong riffles are frequent, especially for some miles above and below the mouth of Husky Dog creek, but no strong rapids necessitating portages occur below Cache creek. Two and a half miles above this is the Big Alec rapid, a rough bed-rock rapid a quarter of a mile in length. Above this rapid the stream continues very swift as far as examined.

Rapid current.

The direction of the North fork is generally a few degrees north of east, except in one stretch 10 miles in length commencing 25 miles above its mouth measuring along the valley. The river at this point enters an old valley running nearly magnetic north and south and follows it north to the mouth of Husky Dog creek, then leaves it abruptly and continues its easterly course. The old valley just referred to extends south to the South fork, and north probably to the Stewart and is occupied in turn by a number of streams along different portions of its course.

Tributaries of North folk.

The principal tributaries of the North fork are Barr, Husky Dog and Cache creeks from the north and Clearwater creek from the south. These streams all carry considerable volumes of water, and occupy deep, wide valleys. Cache creek, the only one examined, has a width of about 50 feet, and a length measured along the valley of 20 miles. The valley of this creek is wider than that of the main stream and extends through to the South fork of the Stewart. The summit is close to the Stewart valley and the drainage is all southward.

Selwyn range.

Topography.—The North fork below Barr creek is bordered on the north by a long ridge and on the south by a high wooded plateau. Six miles above Barr creek the river bends suddenly northward, between two lofty mountain ranges, and for the remainder of its course traverses a continuously mountainous country. The name Selwyn range is proposed by the writer for this group of mountain ranges, The summit range of the Selwyn mountains forms the Yukon-Mackenzie watershed—and the whole group may be considered as one of the sub-ranges of the Rocky mountains. The central portion of the range is drained on the west by the North fork of the Macmillan and the South fork of the Stewart and on the east by Gravel river, all large, rapid streams. The north and south limits of the range have not yet been defined.

Description and height of.

Selwyn range differs from the main range of the Rocky mountains further south in consisting of a number of irregular groups

of mountains and not of a series of parallel longitudinal ridges. This feature is due largely to the presence in the range of several large granite masses, cutting the argillites and cherty rocks of which the mountains are mainly formed. The mountain groups are occasionally separated from each other by wide, low passes connecting the main drainage line. The mountains have a height of from 3,000 to 5,000 feet above the valley, or from 6,000 to 8,000 feet above the sea. Their general appearance is rather subdued, as the argillites and cherts when horizontal, or nearly so, weather into rounded elevations without marked individuality. The sculpturing in the granite areas is, however, bolder and more rugged, and the shattered pinnacled crests which often surmount the ridges of sharply tilted cherts and agglomerates, give variety to the view.

The South Fork of the Macmillan.

The South fork at its entrance to the main river is very unlike the North fork. It is rather wider, having a width of 250 feet; the current is slack for several miles above its mouth, the colour of the water is much darker and the temperature slightly higher than that of the North fork. The stream as far as examined has many of the characteristics of the main river. For the first twenty-five miles, following the windings of the stream, the average grade is about three feet to the mile; from this to the canyon the grade is probably five feet. The speed of the current varies from two to five miles an hour, with occasional accelerations. Fifty-eight miles from the Forks is a canyon about half a mile in length, the river breaking into three rapids on its course through it. Beyond the canyon the valley widens out, the grade increases and the river runs swiftly around sharp bends and resembles the North fork in character during the remainder of its course.

South fork Macmillan river.

The general upward direction of the South fork is south-easterly, but toward the head it appears to bend to the north, and one of its upper branches heads quite close to those of the North fork. The first tributary stream enters the South fork from the south at a distance of twenty-four miles from the Forks; beyond this are several small streams coming in from both sides. The principal tributary is Riddell river entering from the south, forty-six miles from the Forks. This river is 125 feet wide, the water is of a brown colour, and the current is slack, moving at the rate of about two miles an hour at the lower portion; the grade increases slightly, higher up the stream, with occasional small riffles.

General direction.

Principal tributary.

Twenty-six miles above its mouth Riddell river divides into two branches of about equal volume, the one from the south coming in with

Branches of Riddell river.

the velocity of a torrent. Beyond this the easterly branch is still water for about a mile, then becomes swift and the river from this part onward is impassable with canoes.

Topography.—The valley of the South fork bears such close resemblance, both in grade and cross section, to the main river valley, that it may be regarded as a continuation of the latter.

For about ten miles by the valley above the Forks the South fork is bordered on the south by long ridges of fairly regular outline rising from 500 to 1,200 feet above the valley; these slope gently back from the river banks and are thickly covered with moss and small spruce. Beyond this the ridges become lower and recede from the river, the valley widening out on both sides. Sixteen miles, by the valley, from the Forks is a very pronounced depression to the north of the river. This depression runs through to the North fork, a distance of about eleven miles. The nature of the floor of this valley is concealed by a thick growth of small spruce and a deep covering of moss, but from the absence of rock exposures and the presence of numerous small lakes it is assumed to be an old valley of erosion, partially filled up by deposits of loose material of glacial origin. The floor of this valley rises to a height of 300 feet above the level of the South fork, and to about 170 feet above the North fork.

Probable old valley.

East of this valley and on both sides of the river are mountain groups, those to the north rise gradually by a series of ridges and culminate in several lofty peaks, which form an important spur of the Selwyn range. The group to the south is known as the South Fork mountain, and bears a rough resemblance to an elevated table land. The watershed of this group is close to the South fork and one of its chief features is the deep channels which the streams have cut in its flanks. Here are seen gorges V-shaped, with walls sometimes 500 feet in height.

South fork mountain.

Beyond the canyon the valley opens out again and widely isolated groups of high mountains are to be seen in the distance to the east and south, while the intervening country presents a succession of low parallel ridges with even outlines. Riddell river flows through this rolling country, slowly cutting down its bed in sand and gravel deposits.

Terraces.

Terraces, well preserved and continuous, are to be seen in this part of the valley; the highest well marked ones were found at an elevation of 600 feet above the river level, or 3,000 feet above the sea.

FORESTS.

The principal tree found along the valley of the Macmillan is the white spruce *(Picea alba)*. This tree is found both in the valley bottoms and on the mountain sides to a height of 2,800 feet above the valley at the mouth of the river and 1,800 feet above the valley at Cache creek. Groves of white spruce with trees measuring from one to two feet in diameter occur on most of the river flats and alluvial islands, and in a few localities individuals of this species were seen which measured three feet in diameter. The groves are small as a rule, but the aggregate amount of good spruce timber in the valley is considerable. Among the other trees noticed may be mentioned the black spruce *(Picea nigra)*, the aspen *(Populus tremuloides)*, the balsam poplar *(Populus balsamifera)*, the black pine *(Pinus Murrayana)*, the balsam fir *(Abies subalpina)*, and a birch (probably *Betula papyrifera)*. The black pine occurs in large groves on the benches along the lower part of the Macmillan valley and was traced eastward for thirty miles beyond the fork. It seldom exceeds nine inches in diameter. The balsam fir occurs mostly on the mountain slopes and was seldom seen on the river flats. It is found all the way to the tree line, but seems to thrive best at an elevation of 1,200 feet above the valley, the trees gradually decreasing in size above and below this elevation. The birch is usually small and not very abundant.

Timber.

White spruce and black pine plentiful.

The forest along the main Macmillan and up both forks for some distance is fairly luxuriant and very similar to that on the Lewis and Upper Yukon. On the upper portion of the North fork the trees are much smaller and more scattered, and the prevalence of white reindeer moss on benches and mountain slopes contribute a sub-arctic character to the landscape.

GEOLOGICAL SECTION ON THE MACMILLAN AND DOWN THE PELLY RIVER.

The Macmillan valley does not afford a good geological section, as it is filled with glacial drift and bed-rock is seldom exposed. The frequent long gaps in the valley section, rendered necessary an examination of the bordering ridges and mountains, on all of which good exposures were found. Some time was spent on the Pelly below the mouth of the Macmillan, as only a hurried examination of the rocks was made by Dr. Dawson in 1887.

Macmillan valley filled with glacial drift.

Steep mural cliffs of basalt occur along the right bank of the Pelly above its mouth and rounded hills of massive grey biotite granite on the left bank.

Basalt cliffs

The basaltic plateau occupies the angle between the Pelly and the Yukon and extends down the latter river about twelve miles. It has a height of about 520 feet. A typical well-preserved volcanic cone built largely of vesicular basalt occurs a few miles north of the Pelly. The cone has a height of 2,570 feet above the river, and of about 1,000 feet above the general level of the country in its vicinity. The crater in the summit of the cone has a depth of 450 feet and a width at the bottom of 300 feet.

Comparatively recent lava flow.

The last lava flow, now represented by a ridge of basalt fifty feet high, escaped through a break in the encircling wall of the crater and streamed to the eastward. The date of this volcanic cone is comparatively recent as its outlines have not been modified by denudation to any material extent. It is unlikely that all the basalts in the vicinity issued from this cone and it is probable that other vents will be discovered when the country is closely examined. The basalts are replaced four miles up the valley by grey biotite granite, and the latter, five miles further on, by crystalline schists.

Crystalline schists.

The schists include several varieties, the principal one being a hard quartz-mica schist evidently an altered clastic, garnetiferous schists, chloritic and hornbledic schist, and bands of white crystalline limestone. These rocks are associated in places with granite-gneisses and evidently represent the Nasina series described in previous reports as occurring on the Yukon and Stewart rivers and in other localities. They have an east and west strike, and outcrop along the river in frequent exposures up to Willow creek, a distance of over twenty miles. East of Willow creek the Pelly winds through a wide depression filled with glacial deposits, and destitute of exposures of older rocks. The depression extends southward along Mica creek, the outlet of Tatlmain lake and may be underlain by the Cretaceous coal-bearing rocks which cross the Lewes at the Five Finger rapids. Drift lignite was found on Mica creek, and also on the Pelly below the mouth of this creek.

Granite gneisses similar to those in Yukon valley.

The hills which border the depression, just mentioned, on the northeast consist of sheared granite-gneisses similar to those along the Yukon valley, and evidently like them of eruptive origin. They are concealed along the river but outcrop in Knob Hill, north of Willow creek and Ptarmigan mountain, south of Granite canyon and also at one point above Gull rock in Granite canyon where they project up into the andesites.

The granite-gneisses are overlaid in the valley of the Pelly for some miles below Granite canyon by andesites, and these rocks form the

high valley walls in the lower portion of the canyon. The andesite is associated in a couple of places with soft yellowish tuffaceous sandstones and dark carbonaceous shales. The latter at one point near Gull Rock pass into an impure lignite. These carbonaceous beds are probably of the same age as the lignite-bearing beds at Five Finger rapid which hold Cretaceous fossils. **Carbonaceous shales.**

East of Gull Rock, a name given to a sharp splinter of andesite forty feet in height in midchannel, the canyon walls consist largely of volcanic bombs. The upper part of the canyon is cut through coarse gray massive granite. Between the upper end of Granite canyon and the mouth of the Macmillan, the rocks exposed in the valley consist of chlorite and sericite schists, passing in one place, into an augen gneiss. These rocks resemble the Klondike schists which are known to be, in part at least, of eruptive origin.

Macmillan River Section.

The Macmillan mountains north of the lower part of the Macmillan river consist largely of a quartz schist or felspathic quartzite, the precise character of which has not been determined. This rock is coarsely schistose, varies in colour from white to black and is jointed at right angles to the bedding planes. It is interbanded with dark argillites, mica schist and crystalline limestone. **Geological description of Macmillan mountains.**

A couple of rocky bluffs south of the river, one 1,000 feet in height, are built of white coarsely crystalline limestone containing numerous fragments of crinoid stems, probably indicating Carboniferous age. The limestones overlie chlorite and sericite schists, on which they probably rest unconformably Several small areas of eruptive rocks, mostly granite and andesite, occur in the Macmillan mountains.

The Macmillan mountain beds have a general N.W. and S.E. strike and dip to the S.W.

They are succeeded and apparently underlain, ascending the river, by hard dark argillites, passing in places into quartzite bands and inclosing occasional beds of limestone. These rocks are well exposed in the southerly slopes of Kalzas mountain, and farther to the east in Lone mountain and the summit of Dromedary mountain. They are cut off at the summit of Kalzas mountain by granite, and are apparently underlain on the north-east by a band of breccias or agglomerates consisting mostly of angular fragments of dark and occasionally green and red cherts, imbedded in a siliceous matrix. The chert breccias form the eastern part of the Kalzas range

and also outcrop in the lower slopes of Dromedary mountain south of the river.

The chert breccias are followed, apparently in descending order by slates, alternating in places with dark cherts, and then by a great series of tuffs, grits, quartzites and red, green, gray and striped slates and schists. The red slates and associated rocks occur along the Macmillan from a point a few miles above the mouth of Moose river up to the Forks and beyond. They form the greater part of Plateau mountain north of the Macmillan and the Russell mountains east of Russell creek. A wide band of dark brittle cherts interbanded with the red slate series crosses Plateau mountain west of the summit, and massive amygdaloids, passing in places into a schist, outcrop north of the valley a few miles below the mouth of Russell creek.

The red slate series, like the beds in the lower part of the river, have general north-west and south-east strikes and south-west dips. The attitude of the beds apparently indicate a descending series from the mouth of the Macmillan to the Forks, but the regularity of the dip is probably due in large measure to faults and over-turn folds.

Rocks divided into two groups.

The rocks along the main Macmillan may be divided tentatively into two great groups. One group consists of argillites, quartz-schists, quartzites, and limestones and the other largely of volcanic fragmental rocks including tuffs, felspathic grits, and red, green, brown and striped schists. The latter group are interbanded with and are overlain by cherts and argillites, above which are chert-breccias.

Section of the North Fork.

Great thickness of cherts.

Striped and green schists belonging to the red slate series are exposed on the North fork for some miles above its mouth and are then replaced by dark argillites holding occasional beds of limestone. The argillites are less altered than the red schists and associated beds, and the cleavage planes are subordinate to the bedding planes. They are probably the equivalents of the argillites and cherts which overlie the red slate series on the main river above the mouth of Moose river. These argillites have a wide distribution as they are found all along the North fork up to the mouth of Cache creek and on the lower part of Cache creek. Above the mouth of Husky Dog creek they alternate with dark, brittle, flinty beds, which are referred to as cherts, and are largely due to an infiltration of the argillaceous beds by amorphous silica. These cherts occur both in thin beds, and in bands up to a thousand feet or more in thickness. They are the most prominent rocks in the Selwyn range.

The schists and quartzites of the red slate series were noticed at several points along the North fork, especially in the vicinity of the eruptive masses but no large areas were determined.

The argillites and associated cherts are replaced near the head of Cache creek by an alternating series of chert breccias, shales, and dark limestones at least 5,000 feet in thickness. The chert breccias resemble those in the Kalzas range north of the main Macmillan and are apparently a repetition of the same series. The angular chert fragments, the principal constituent of the breccia, are precisely similar to the chert beds and bands found lower down the river and are no doubt derived from them.

The North fork section may be summarized as consisting of three sets of beds, viz.: a lower series of red, green, and striped schists, with tuffs and quartzites, a middle series of argillites and cherts, and an upper series of chert-breccias and shales.

South Fork Section.

The rocks on the South fork of the main Macmillan are similar to those on the North fork. The red and green schists occur near the mouth, but are soon replaced by argillites and cherts, and the latter twenty miles above the Forks are followed by chert breccias, shales, sandstones and limestones which continue as far as the mouth of Riddell river. Beyond this the rock is principally shale of a compact variety, which becomes hardened and altered near the intrusive masses. The mountains to the north of the river are composed of granite and those to the south of andesite. The latter rock cuts through the shale of the valley at a height of about 1,500 feet above the river. Rock section on South fork of main Macmillan.

About eleven miles above the mouth of Riddell river several dykes cut the shales. These dykes harden the latter, which here form the walls of a narrow canyon about half a mile long. The bed rock of Riddell river is a soft, crumbling, black shale with occasional harder beds. The age is uncertain as no fossils were found, but they are probably younger than the chert-breccias.

Granites and allied rocks and andesites occur at several points along the Macmillan and its tributaries, but as the specimens have not been examined microscopically, only a brief reference will be made to them here. A number of irregularly distributed granite areas occur in the Selwyn range, where they form the central portions of some of the principal mountain groups. Igneous rocks.

The granite is of the usual gray biotite variety, is often strongly jointed and weathers into conspicuous cliffs and bold rocky summits. Areas of granite also occur east of Russell creek, on the northern portion of Kalzas mountain, and crossing the Pelly river a few miles below the mouth of the Macmillan.

The South Fork mountains were found by Mr. Keele to be built largely of andesites, and small areas of this rock occur on the Macmillan mountains, and also at the Granite canyon on the Pelly. The andesites are much younger than the granites and at the Granite canyon are associated with lignite-bearing beds of probably Cretaceous age.

General Glacial Features.

Glacial action.

During the glacial period a glacier descended the Macmillan river valley from the Selwyn mountains to its mouth and continued down the Pelly river to a point about 20 miles above Fort Selkirk. Glacial groovings and striæ occur at a number of places along the bottom of the valley, and on the lower slopes of the mountains bordering the valley up to a height of 1,200 feet. The direction of the ice flow was westerly and coincided very closely with that of the valley. The thickness of the ice, judging from the height at which foreign material was found, was 3,000 feet in the western portion of the Selwyn mountains, 3,300 feet at Dromedary mountain, and 2,000 feet at the Macmillan mountains. The upper surface of the glacier appears to have been nearly level from the Selwyn mountains to Dromedary mountain, the slope being less than that of the present valley, but west of this point the western declination averaged nearly 200 feet to the mile.

Higher peaks of mountains show no trace of glaciation.

The ice even in the Selwyn mountains did not cover the higher peaks or, if it did, has left no trace of its presence, and while the valleys and depressions in the broken country to the west were deeply submerged all the principal elevations remained uncovered.

Glacial deposits.

Foreign material in the Macmillan mountains is found up to a height of 2,000 feet. Below this elevation the slopes are comparatively smooth, but above it the harder bands of rock often project above the surface in crumbling walls and loose rocky points which show no evidence of ever having been disturbed except by the ordinary agents of sub-aerial denudation.

The deposits of the ice period, consisting of boulder clays, gravels, sands, silts, and clays, are exceedingly irregular in distribution and sequence and indicate rapidly changing conditions along the valley.

Beds of gravel, evidently deposited by running water, fine silts which have slowly settled down in still water, and glacial boulder clays often alternate several times in the same section.

Boulder clay occurs in disconnected patches all along the Macmillan valley, and down the Pelly for some distance below the junction of the two streams. The heaviest and most continuous deposits of this material noticed occur on the Pelly river above Mica creek, near the western limit of the glaciated area. Sections at the cut banks along this portion of the river show a bed of typical boulder clay, filled with glaciated boulders, forty feet in thickness.

Thick bed of boulder clay.

The upper surface of the boulder clay bed is level and is covered with rolled gravel alternating in places with sand. A layer of large boulders occasionally occurs at the bottom of the gravels.

Besides the main boulder clay bed at the base of the glacial deposits, several smaller beds alternating with silts, sands and gravels are exposed higher up in the face of a steep terrace which follows the river on the north. The section is concealed in places and a complete record could not be obtained. Granite boulders foreign to the locality occur on the hill sides at this point up to a height of 850 feet above the river.

The boulder clay is underlaid in some places by a bed of rolled gravels, but frequently rests directly on the bed-rock. It is overlaid as a rule by silts, sands and gravels, inclosing occasional beds of boulder clay. These deposits are exceedingly irregular and their sequence varies in every section examined. The thin silt beds are often folded around irregular patches of coarse gravel of from three to six feet in thickness and in places are sharply flexed and even overthrown.

Silt beds peculiarly folded.

The reason for this singular attitude of the silt beds is not clearly understood, as the movement which produced them, if it were movement, did not affect the associated coarse sands and gravels.

It is possible that the folding in some instances was caused by the pressure of ice descending the valley and dragging over the beds, but this explanation does not appear to be of general application. In some cases the appearance of the beds suggested the deposition of the silt beds in quiet water around masses of gravel brought down into the valley by torrential side streams. The peculiar folded character of the silt beds overlying the boulder clay in the Macmillan valley was also noticed in previous explorations on the Teslin, the Lewes and the Stewart.

The boulder clay in the lower part of the Macmillan valley is overlaid by an important clay bed at least 200 feet in thickness. The clay

Important clay bed.

is bluish in colour, is indistinctly bedded and is very plastic, rendering it peculiarly liable to slides. The clay is very pure as a rule, but in places appears to pass upwards into a silt. It is overlaid by sands and gravels. The clay bed was traced from the mouth of the Macmillan up the valley for sixty miles, but is not found on the Pelly below the mouth of the Macmillan.

It was evidently deposited in a long narrow lake of considerable depth, probably held in by an ice dam at the mouth of the Macmillan.

The lower slopes of the mountains where it occurs are faintly terraced up to a height of at least 1,500 feet.

The alternating and irregular beds of silts, sands, gravel and boulder clay which form the upper part of the glacial deposits along the Macmillan valley evidence a period of rapid and complex changes, since quiet water, swiftly running streams and ice, are all necessary to explain them. The surface of the narrow valley-plain built up by these deposits is always more or less pitted, and in places is formed of a complicated series of interlacing ridges, some of them evidently of moranic origin inclosing pits and basins often fifty feet or more in depth. A section of one of those ridges showed it to consist mainly of coarsely stratified sands and gravels with some soft boulder clay.

The sand and gravel beds possessed a rough anticlinal attitude, corresponding in a general way with the outline of the ridge, but much flatter.

Drift deposits variable in thickness.

The thickness of the drift deposits along the Macmillan is variable but usually measures from 400 to 500 feet. Kalzas river, one of the main tributaries is lined with conspicuous terraces up to a height of 900 feet.

Lakes are common throughout the glaciated district. A number of small lakes occupying shallow rock basins occur in the granite ranges of the Selwyn mountains, and the pits and hollows inclosed by the morainic ridges are often partially filled with water.

The larger lakes like Moose lake and Kalzas lake occupy long depressions in the glacial plains, probably produced in some cases at least by the thawing out of masses of ice left behind on the retreat of the main glacier.

Another class of lakes common in all the valleys simply represents abandoned portions of old river channels.

ECONOMIC GEOLOGY.

The Macmillan river has not so far produced any gold, although it has been more or less prospected along its whole course. Fine colours are present everywhere, but no pay bars, such as have been worked on the Stewart, Pelly and other tributaries of the Yukon, have been discovered. The old quartz-bearing schist and gneiss which contribute the gold to these streams are replaced in the valley of the Macmillan by younger formations, none of which have proved to be notably auriferous.

Macmillan river not gold producing.

The most promising formations for minerals of economic value are the quartz schists and accompanying chlorite, and sericite schists near the mouth of the river and the wide band of red, green and dark schists and associated rocks which crosses the valley in a diagonal direction at the Forks and extends up and down the river for a considerable distance. Both these formations are cut by occasional quartz veins and silicified zones, but the few specimens collected proved on analysis to be barren. Argillites heavily impregnated with pyrite occur in Lone mountain and also in Dromedary mountain. Specimens were analysed but yielded nothing of value.

Gold reported on Russell creek.

The only tributary of the Macmillan on which coarse gold has been definitely reported is Russell creek. This stream enters the Macmillan from the north, four miles below the Forks, and cuts through the red schist series referred to above along its whole course. A mining concession embracing the larger part of the main valley has been granted to a company, but no work was in progress during the past season and no definite information in regard to values was obtainable. Some prospecting was done above and below the concession during the season, the results of which were not considered favourable, although fine colours and an occasional coarse colour were obtained.

Favourable conditions for working.

Russell creek occupies a wide heavily glaciated valley, floored, especially in the lower part, with heavy deposits of silts, sands and gravels mostly of glacial origin. This drift material thins out gradually ascending the valley, and near the summit the bare rocky floor of the old valley bottom is often uncovered. The present stream occupies a narrow depression sunk through the drift deposits down into the bed-rock beneath. The grade of the stream is heavy, averaging 100 feet to the mile, the flow of water in the main stream and also in some of the steep tributaries is ample for hydraulicing at all seasons and the conditions are generally favourable for cheap working. The prospecting done up to the present time has proved the presence of coarse gold in the creek, but has done little more. The extent of the auriferous gravels and their average value still remains to be determined.

Boring necessary to prove existence of lignite beds.

A small seam of carbonaceous shale or impure lignite, of no value, occurs at Granite canyon on the Pelly, and drift lignite, as stated on a previous page, was found on Mica creek. It is highly probable that lignite-bearing beds underlie the comparatively low country along Mica creek, but, as no surface exposures were seen, definite information on this oint can only be obtained by boring.

A shaft sunk on an easterly branch of Mica creek, about eight miles from the Pelly, is reported to have passed through several small seams of lignite.

The Climate and Flora of the Yukon District.

Professor John Macoun.

Work done by botanical branch.

During the past year, the routine work of my office has continued to increase and much of my time has been employed in determining specimens and replying to queries from working naturalists throughout the Dominion. During the winter and early spring months, the proofs of Part VII of the Catalogue of Canadian Plants were read and revised and this report was printed before my departure for the field in June.

I am now completing the manuscript of the second part of my Catalogue of Canadian Birds, which will be printed this winter. In conjunction with Dr. Theodor Holm and James M. Macoun a flora of the Hudson Bay region has been written, which will be published next autumn. In the office work I have been assisted by Mr. James M. Macoun and Miss Stewart. The time of the former has been chiefly employed in determining specimens, while Miss Stewart has been engaged in writing labels and filing letters.

Specimens sent for determination.

A record has been kept of the number of specimens sent for determination to my assistant or myself, and, without including the collections brought in by members of the Geological Survey staff, these number 1,644 sheets of specimens. The largest of these collections were from Anticosti (375 specimens) and St. Laurent college (314 specimens), while smaller lots were received from all parts of the Dominion. My own collections, made in the Yukon, embrace a large number of specimens, many of the species being new to science. These are as yet undescribed. Mr. James M. Macoun brought from southern British Columbia a very large collection of plants, birds and mammals upon which he is now working.

Since the last summary report was published 3,226 sheets of specimens have been mounted and placed in our herbarium.

Of these 1,858 were Canadian flowering plants, 927 were foreign and 441 were cryptogams ; 3,461 specimens were distributed from the herbarium, chiefly in exchange for specimens received in previous years. One hundred specimens were purchased and 832 were received from foreign correspondents.

Miss Stewart, our clerical assistant, has during the year spent a portion of her time assisting the librarian. In addition to her work before referred to she has completed the numbering of the herbarium sheets of flowering plants, of which we have 57,961 ; of these 34,289 are Canadian.

Examination of Klondike country.

Reports on the character of the country and the climate in the vicinity of Dawson, Yukon district, differed so much from one another and were so contradictory that I was instructed to make an examination of the Klondike district during the summer. I made the necessary preparations and left Ottawa on June 27. On my arrival in Vancouver, I waited two days for a boat, and on the morning of July 5, left for Skagway on the steamer *Amur*. At 10 p.m. on the 7th I reached Skagway and left the next morning for White Horse, reaching there at 4.30 p.m. At 8 p.m. the same evening I took the boat for Dawson and reached that city at 8 a.m. on the morning of the 10th.

Work in the vicinity of Dawson.

Work was commenced the same day and I collected specimens and made notes in the vicinity of Dawson until July 21, when I went up Hunker creek and examined the country for miles around. I remained there until August 3, when I returned to Dawson. After a few days, I took the stage to Gold Run creek, a distance of forty-eight miles. The road passes up Bonanza creek and over the Klondike—Indian divide, and then down Gold Run creek to Dominion creek. This trip enabled me to see a large section of the country and assisted me very much in my final opinions regarding it.

By the last week in August I saw my work for the season accomplished and started on my return to Ottawa on August 25. On my way up the river I purposed stopping at Fort Selkirk, but, owing to a severe cold, I was forced to push on to White Horse which I reached on the 29th. Four days were spent at White Horse and then I proceeded to Skagway and finally reached Ottawa on September 15.

The day has passed when the trip to Dawson means either difficulty or danger above the ordinary, but the element of time is still considerable. If close connections were made, the trip to Dawson would require only ten days and the return trip thirteen days.

Description of the route from the White Pass to Dawson.

Cross White Pass.

We crossed the summit of the White Pass at an altitude of 2,952 feet and began to descend at once to the north. Here we were above the tree line, and bare mountain slopes, broken rocks, pools of water and a truly arctic or high mountain vegetation showed the climate to be cold, while the stunted and broken trees lower down indicated the immense snowfall which is characteristic of the whole coast range.

As we descended towards Lake Bennett the vegetation rapidly changed and stunted firs (*Abies amabilis*) gave place to small spruce trees and the high mountain shrubs and herbaceous plants began to be replaced by forest species. Little time was available for making collections, but the species collected were those found at an altitude of 6,000 feet in the Selkirk mountains. At the head of Lake Bennett, where we had lunch at 2,170 feet altitude, an agreeable change was noticeable and the vegetation had much improved. The mountain summits, however, showed that we were not far below a chilly atmosphere.

Railway follows east side of Lake Bennett.

The railway keeps to the right or east side of Lake Bennett and a very little below Bennett station it takes a slight turn to the east. The cold winds from both the Chilcat and Chilcoot passes seem to be cut off and a most astonishing change takes place in the vegetation. Our train reached the point where the trains cross, some time ahead of the train from the west, and quite a collection of plants was made and numerous species indicating a mild climate were obtained. Amongst them a species of rose (*Rosa acicularis*) was found in bud. Two days later the same species was gathered, with fruit half grown, at Dawson four degrees farther north.

Fine climate at Caribou Crossing.

At Caribou Crossing, 24 miles from Bennett, without descending one foot, the whole vegetation had changed and everything indicated a genial climate. Since then I have learned that next year farming on an extensive scale is to be inaugurated at this point. It is true that the soil is light sandy loam at the crossing, but it is said to be better eastward along the lake.

Gardening successful.

The general character of the valleys from Caribou Crossing to White Horse varies little, but there is a gradual change of climate as indicated by the vegetation. There is evidently less rainfall and, outside of the river valley, more sand. Although I reached White Horse in Lat. 60° on the 8th July, I found the wild flowers past their prime and asters and golden rods, that would not flower in Ontario until August, were beginning to ripen. This was a new town a year ago, yet attention has already been given to gardening by the steamboat owners.

Although White Horse is very far south of Dawson, its climate is far from being as good as that of Dawson, but the past summer all who have tried have been successful in bringing vegetables to maturity. When there in September, arrangements were being made for more extensive cultivation next year.

Nature of forests.

The character of the forest along the Yukon varies according to locality. The trees vary greatly in size and in no case can the forest be called heavy. There are many groves in the river valley where the trees are tall and stand pretty close together. These are the exception, however. In general the trees are under a foot in diameter but many run to 20 inches. On the slopes near the river they are generally small and not so tall as in the river valley.

Back from the river occasional glimpses were obtained of wooded slopes which seemed to have a covering of fair sized trees. As no stoppages were made except to take on wood, there was no chance to see anything except from the deck of the steamer. The forests along the Yukon cannot be compared with those of any other region because they exist under different conditions. The Yukon flows from south to north with a tendency to the west. This gives almost constant sunshine on the east or right bank of the river and hence many of the cliffs and mountain slopes are covered with grass. Often for miles only scattered trees can be seen on this side of the river. On the left bank everything is changed. Here the steep slopes have small trees but where the slopes are less abrupt and more exposed to the sun the trees stand closer together and are apparently much larger. This may be said to be the general character of the river banks all the way from White Horse to Dawson.

Prevailing trees.

At White Horse the forest outside the river valley is composed of lodge-pole pine (*Pinus Murrayana*), but in the valley from there to Dawson black and white spruce are the prevailing trees. White spruce is the chief wood used on steamboats, and indeed for every purpose except as firewood at the mines, where black spruce and birch (*Betula resinifera*) are largely used. Aspen poplar and balsam poplar are common throughout the country. The latter with willows constitutes the woody vegetation of all but the very oldest islands in the Yukon. On the latter large white spruce trees are often seen standing up straight and tall. The forest in the immediate valley of the Yukon will soon disappear, as many thousand cords are used every year by the steamboats, and rafts are floated to Dawson to be cut up for firewood.

On my arrival at Dawson on July 10, I took notes of the condition of vegetation at that time, and was struck with the advance already made by the native plants and shrubs. Garden strawberries were that day placed on the market at $2.50 per box.

Situation of Dawson.

The first thing that strikes a traveller when he reaches Dawson is its situation. It takes up the whole of a swamp which extends from the mouth of the Klondike to where Moosehide mountain impinges on the Yukon, a mile below. The city is on the right or east bank of the Yukon, which here is about as wide as the Ottawa at the capital, with a current of four or five miles an hour. The city crosses the swamp, and many cabins are built on the mountain side for over 500 feet up its slope.

Drains have been dug along all the streets and surface drains about two feet deep on many of the unoccupied lots. Gradually the frost is passing out of the ground, as many of the houses show that the ground is settling. Attempts have been made in numerous places to make lawns, and although in most cases very little work has been done, timothy has taken well and the lawns of the Presbyterian church and the hospital are growing rapidly, and, after being cut, spring up quickly.

Rapid growth of vegetation due to long summer days.

On Sunday, July 13, nasturtiums and sweet peas were in flower and on the next day an eastern rose bloomed in the garden of Dr. Brown the Territorial Secretary. Owing to the long days of late May and all June, vegetation grows very rapidly, and I was surprised on my first trip up the mountain on the 11th July to see that, even then, most of the flowers had perfected their seeds, though many were still blooming profusely. Roses were long past flowering and their hips were colouring. At about the same altitude, only four days before, I found the same species of rose coming into bloom on the shore of Lake Bennett, over four degrees or nearly 300 miles farther south. The species was *Rosa acicularis*, and Mr. James W. Tyrrell showed me specimens he had gathered in flower on June 2. Last spring Dr. Guillet of Ottawa and myself had been noting the flowering of all species at Ottawa, and this species was first detected in flower in Queen's park, Aylmer, Que., nine miles from Ottawa, on June 3. This one simple fact shows the progress of the spring at Dawson better than a whole series of elaborate statistics, because statistics do not give the amount of heat and light given out in a 20-22 hours day.

On the 12th I collected plants on the mountain and gathered red currants (*Ribes rubrum*), blueberries (*Vaccinium uliginosum*) and mountain bearberries (*Arctostaphylos alpina*) in profusion, fully ripe. Hosts of other plants were in seed and *Anemone parviflora* was blooming the second time. The fruit of the 'prairie crocus' (*Anemone Nuttalliana*) had all fallen and the leaves turned to dust. Every native plant seemed to have almost completed its summer's work at this time. I could find no plants that indicated coldness, so on the

14th I ascended Moosehide mountain immediately in rear of Dawson to see if there were any on it.

Dawson is 1,200 feet above the sea and Moosehide mountain rises 2,050 feet above the city. The mountain as seen from Dawson throws out two long ridges, one towards the Klondike, the other towards the Yukon below Dawson. Both ridges end in steep cliffs facing the above rivers. Paths from many points in Dawson lead to the summit of the Klondike ridge and from there other paths lead to the top.

Ascend Moosehide mountain.

On Monday, July 14, I made my first ascent of the mountain and particularly noted the vegetation. There were many fine species on the lower slope either in flower or seed and intermixed with these were grasses of the genera *Arctagrostis*, *Poa*, *Festuca*, *Calamagrostis* ; and *Trisetum* and *Agrostis* were represented by a single species each. Later I found that these were the commoner grasses of the country.

An umbelliferous plant discovered by Dr. G. M. Dawson in 1887 and named in his honour grew from base to summit. The plant in question is *Selinum Dawsoni*. The Carices were altogether eastern and ascended to 3,000 feet on the slope. Pale corydalis (*Corydalis glauca*) was abundant on burnt land and the western form of *Corydalis aurea* was occasionally seen. The great willow herb (*Epilobium spicatum*) was in profusion everywhere and indeed is the common fire weed of the Yukon as it is in British Columbia and the east.

Vegetation noted.

Aspen poplar (*Populus tremuloides*) was abundant, white spruce (*Picea alba*) covered all the dry slopes, and the black spruce (*Picea nigra*) was everywhere else, including all swamps and slopes facing north at any altitude. After climbing about 1,000 feet above Dawson, an alder (*Alnus fruticosa*) taking a tree form was not uncommon. Another common tree was a birch (*Betula resinifera*) which averages about six inches in diameter and is much used in Dawson for firewood.

Forest trees.

As I ascended higher, many other species of plants came in, but a species of Polemonium occupied more ground than all the others put together. Another prominent and beautiful species was a golden-rod (*Solidago oreophila*) which is characteristic of the Yukon and extends to White Horse. At about 2,000 feet altitude, the flora changes and *Saxifraga tricuspidata* and *reflexa*, *Arenaria lancifolia* and other species make their appearance. About 500 feet higher up, the same species were found in seed and everything else indicated more warmth than was evidenced by the development of the vegetation lower down. Speaking of this fact later in the summer and deducing from it that the air was constantly warmer 1,000 feet above Dawson in the summer than in the city, I was imformed that this was specially true in the winter as it was a common occurrence for parties to go up the

Evidence of higher temperature 1,000 feet above Dawson.

mountain in winter to get warm. These statements taken together will be referred to again in this report.

Plants found on extreme summit of Moosehide Mountain.

On the extreme summit *Potentilla nivea* was in seed and around were *Cetraria nivalis* and *cuculata* and rock lichens that are found at Banff in the Rocky Mountains. Coming down I collected a fine aconite (*Aconitum delphinifolium*) and a larkspur (*Delphinium glaucum*)and noted many species not hitherto seen. A large perennial species of Polygonum, looking much like buckwheat, grew in many places and was quite showy with its tall branching stem (about five feet high) and its long racemes of white flowers.

A very extensive view to the east is obtained from the mountain summit, and I was extremely surprised that the Ogilvie mountains which lay beyond a wide plain, about 40 miles off, were altogether without snow except small patches lying in deep hollows. Although their summits were at least 8,000 feet above the sea, they were entirely bare. This panorama of mountain and plain without a sign of cold in lat. 64° 15′, set my mind to work to find out why this could be, and I have solved the riddle to my satisfaction in my paragraph on climate.

The 15th was spent in the Klondike valley and here also new revelations awaited me. The islands in the river have been cleared of brush and trees and in their stead gardens have been established in which vegetables of all kinds come to perfection. From these gardens the citizens of Dawson are supplied with rhubarb, radishes, lettuce, onions, turnips, beans, parsnips, carrots, peas, cabbage, cauliflower, Scotch kale and many other pot-herbs. Everything was in an advanced stage and gave certain promise of a large crop.

Vegetables grown successfully.

All the above vegetables have passed the experimental stage and nothing is necessary to success but care in the cultivation. Collections were made in the valley and many interesting plants were obtained which will be brought out with more prominence in another report.

Next day, July 16th, I crossed the Yukon by the ferry and visited the gardens and farm in West Dawson. The gardens are on the flat along the Yukon, and seem to have been established before any others in the district. Everything was in a forward state for the season. Munro's farm is on a hill about 300 feet above the river and about a mile west of the gardens alongside of it. Here was actual farming, and, besides the usual garden vegetables, there were at least 25 acres of oats which had been sown for fodder. To the north of the oat fields 25 acres were cleared and were being broken up for a summer-fallow.

On August 6 I again visited this farm and found a marked change in the growth of the oats. Some of the seed had been sown late and some early, but the greater part late and on freshly broken ground. As a result of this the crop was patchy and tall and short grain grew in close proximity. The land ploughed the year before produced the earliest and best growth of straw. Nearly all the grain was in the milk, but where there evidently had been a crop last year I pulled up specimens of wheat, barley and oats that were far advanced towards maturity. Fine specimens of oats were gathered that were colouring and had very remarkable grain. Instead of one full grain and an abortive one in the fascicle there were always two and often three. This condition I had never seen before, but it seems to be universal at Dawson, as later I noticed it in other fields. Visits paid to Munro's farm.

On August 23rd I again visited Munro's farm in West Dawson. He was then cutting his oats for fodder. In his latest oats the volunteer barley was all ripe and this was not sowed until June 5th. In this case the barley ripened in 79 days. Tables in my possession show that there is no frost from May 23 to August 23, or 91 days. Barley ripens in 79 days.

After collecting and making notes around Dawson until July 22nd, I removed to Hunker creek near Gold Bottom creek. From this as a centre I examined the country for several miles around, and learned many things that I had not clearly understood before. Many opinions are expressed regarding the deposition of gold, the depth of the frost in the ground, the occurrence of fossil bones in the gravel and other matters that it is not my province to discuss in this place.

The earlier reports led me to think that the whole country was covered with a thick coating of moss, and that beneath it there was permanent frost. Other reports were that there was no wood of any account in the country and scarcely any at Dawson. All these statements were partly true, but so far from the whole truth that they were virtually untruths. During the two weeks I spent on the creeks I made a special study of the prevailing conditions and am able to give a clearer view of the situation than I had when I went there. Earlier reports misleading.

Owing to the high latitude of Dawson, 64° 15′ north, the altitude of the sun above the horizon is never very great. For nearly three months, however, there is scarcely any darkness and the sun is above the horizon over three-fourths of the time. The rainfall and snowfall are both light. This light deposition, combined with so much sunshine, gives much warmth, and on exposed soil great evaporation. These conditions are so varied that while on one side of a creek there may be two or Conditions very varied.

more feet of moss and beneath that permanent frost, on the other side the soil may be so exposed to the sun that no moss can exist and only the deepest rooting grasses can maintain a foothold. Hence, people talking about deep mosses speak of land facing the north, while those who claim irrigation is necessary have in their minds terraces exposed to the sun. This being the case any one writing on the subject of vegetable growth or the production of crops must take all the circumstances into consideration.

It must be borne in mind that in the vicinity of the Yukon and its tributary streams there is no level land except in the immediate valleys of the rivers, and these are largely swamps. All the mountains are dome-shaped and the ridges that connect them are narrow with sloping sides. The hills are small replica of the mountains, and the sides of all the creek valleys are sloping and not a precipice is to be seen in the country except along the Yukon or Klondike.

Coating of moss causes permanent frost in ground.

In nearly all cases the lower slopes of the creeks, especially close to the water, are covered with a deep coating of moss, and the valley itself is a peat bog chiefly *Sphagnum*. The cause of this is not far to seek. Much of the surface is more or less covered with gravel and the melting snow and rain sink into the soil until the frost is reached when it either changes to ice or runs on the surface of the frozen ground down the slope and oozes out at the base as a series of 'springs,' the thickness of the mossy covering generally determining the extent of the summer thaw. Where real springs ooze out in the valleys or on the slopes, the water freezes into what the miners call 'glaciers,' but these are just the water of the springs turned to ice. This condition has a tendency to increase the depth of the frost as an ice sheet under the moss acts like an ice blanket and keeps out the heat. With these facts in mind any person can see that the cutting down of the forest and the drying up or burning of the moss will completely change the conditions, and permanent frost will not be a noticeable factor in the climate of the Yukon.

Timber small in valleys and lower slopes.

By the above it will be seen that in the creek valleys and on the lower slopes the timber must be very small, which is the case. As we ascend the slope, the trees get larger and taller and at an altitude of nearly 2,000 feet above Dawson the forest assumes the appearance of an eastern one, and trees can be found 20 inches in diameter, with trunks nearly a foot in diameter from 50 to 70 feet from the stump. Trees of this character were found at the head of Gold Run creek and its tributaries. It must not be understood that the forests on the Yukon in the vicinity of Dawson are in any sense like those in eastern Canada. The trees are seldom close together, are generally under 50 feet in height, and it is only under exceptional conditions

that they attain the size mentioned on the preceding page. Much of the timber consists of poles ranging from four to eight inches, the latter size being in the minority. The wood on Hunker creek was of this character and seldom produced two sixteen-foot sticks, into which lengths all cordwood is cut. Before I left Dawson thousands of cords of spruce in sixteen-foot lengths were floated down the Klondike for use at Dawson. These sticks ranged from four inches to a foot or more in diameter, were clean and well grown, and split as straight as a shingle.

Forest represented by eleven species.

The forest in the district visited consisted of eleven species which attain the dimensions of trees but of all these only the white spruce (*Picea alba*) and balsam poplar (*Populus balsamifera*) grew to a considerable size. Black spruce (*Picea nigra*) was abundant in all peat bogs and on the lower slopes of the hills but never became large. Mixed with the black and white spruce were three species of birch, two of which were mere poles, but the third, (*Betula resinifera*), was sometimes eight inches in diameter and supplied most of the firewood consumed around the mines. It was never tall, seldom having a trunk that produced two sixteen-foot lengths for firewood. Three willows and two alders became little trees but were of no use for firewood. Aspen poplar (*Populus tremuloides*) as usual occupied the dry slopes and was mixed almost everywhere with white spruce but was always of small size.

In the Klondike valley about four miles from Dawson, near the mouth of Bear creek, there were a few groves of tall, straight, well-grown balsam poplar and white spruce. These as remnants of an earlier forest showed that the climate was well suited for forest growth, and that the short warm summer with continuous growth gave shapely trees and rapid increase in size.

Soils evidently good.

Attention was given to so many things that in a summary report all can scarcely be enumerated, much less dwelt upon. From what I saw of growing crops I am satisfied that the soils are good. That in the river bottoms was alluvium, overlying the river gravels. On the hills the soils seemed to be chiefly loams, with sometimes sand in greater or less proportion. As no glacier action had taken place the soils were very local in character and largely resulted from the disintegration of the rocks of the locality.

Cultivation will result in earlier ripening of crops.

All attempts at cultivation were apparently successful even in the Dawson swamp. When the ground is properly worked, the soil mixed, and the ice or frost stratum in late summer is found at a depth of eight or ten feet, there will be a complete revolution and all crops will mature much earlier. I took notes, during the seven weeks I was at Dawson, of the growth of all cultivated grains and vegetables, and

below will be found my remarks written at the time. Everything, be it native or exotic, grew surprisingly, and while I never found any cultivated thing a failure, I must say the same of weeds. In every case they were a success and numbers of them were natives of California.

White clover, alsine and red clover as well as timothy grew wonderfully well by roadsides and on dry soil. In the swamp muck of Dawson, much of the clover on lawns, sowed in the swampy soil, looked yellow and had a sickly appearance. Timothy acts similarly; when sowed in the bog it is sickly and yellow-looking, while along dry roads in the woods or on the hillsides it is quite tall and has a seed-head from two to three inches in length.

Yukon district well suited for growing barley.

Barley is certainly well suited to the Yukon district. On August 6th, on the farm at West Dawson, I found grain quite hard mixed with oats that were much later in appearance. On the 18th August, I visited the gardens in West Dawson along the Yukon and found oats being cut for fodder. Mixed with the oats were many barley heads fully ripe and others that had hard grain. In all cases the grain was large. West Dawson was again visited on 23rd August and Mr. Munro was then cutting his oats for fodder. In his latest oats the volunteer barley was all ripe and this was not sowed until June 5 so that the ripening of barley at Dawson is an assured fact.

Oats do well everywhere but are seldom even a fair crop on ground just broken up and then seeded. In all cases I found good oats where sown on second year cultivation. The grain was earlier, taller and better in every way. On August 6th I found self-sown oats on Munro's farm in West Dawson fit to cut, but only a few bunches on dry ground. Barley was ripe at the same time under the same conditions. This showed me that up to that date there had been enough heat to ripen oats and barley if sown early on dry soil. Mr. Munro seemed to realize this, for on August 23 he showed me 21 acres about ready for a crop, that he had already ploughed three times and intended to sow at the earliest possible moment in the spring of 1903. One man of this type will do much for the Yukon, yet hitherto cultivation of the land on a large scale has been almost prohibited by the local authorities, and, up to the time I left, farming was almost illegal as the gold seekers had "blanketted" the whole country.

Farming not in favour.

On my last visit to Munro's farm I advised him to lay his case before the Deputy Minister and, if he did, I am sure that farming in the Yukon will be no longer under disadvantages. There is no reason why all the oats, barley and fodder of all kinds with every vegetable

required in the home should not be grown around Dawson. That this is not so is the fault of local or other laws that give no surface rights to the individual outside of mining rights. Amending the land laws and giving proper encouragement to farming operations will soon place the Yukon district on a basis where it will be self-supporting outside of wheat requirements.

Wheat growing at present uncertain.

In the matter of wheat, I do not speak positively, but I believe that after a few years wheat will ripen on all fairly warm soils, although at present its ripening is doubtful. As far as my investigation went I could find no person who had sown wheat. Mr. Munro had sown oats grown somewhere in the United States, and he informed me that he was led to believe that the wheat mixed with it was spring wheat. Instead, it nearly all turned out to be fall wheat and only made leaves, stooled out and its roots penetrated the soil to a remarkable depth and so remained when I saw it on August 23. That it will ripen next summer is to me a certainty, and I trust Mr. Munro has not ploughed it all under. Of the spring wheat I may say it was generally taller than the oats but scarcely as ripe. All the ears were filled to the tip with grain, and the grain was filled out and since has hardened so as to give the appearance of ripe grain. Since my return to Ottawa I have had the grain tested, and the report on the Yukon wheat received from the grain tester Mr. Ellis of the Experimental Farm, is as follows: 100 grains planted; 100 grains germinated; 100 grains made vigorous growth. Germinations very quick and growth exceptionally good.

When grain ripens in the country and is again sown there, it will take on the conditions of its environment and mature earlier, and early frosts, like those formerly attributed to Manitoba, will have no effect as the crop will mature before they come. I may remark here that the wheat in the North-west ripens earlier now than it did twenty years ago and many people believe it is the climate that has changed whereas it is only the wheat that has adapted itself to its environment.

Potatoes not so far grown to advantage.

Hitherto potatoes have not been up to the standard as regards dryness and general fitness for the table. After making full inquiry into the subject I became convinced that the seed potatoes came from too far south. Acting on this thought, I had a few pounds of early potatoes sent out to Mr. J. B. Tyrrell with instructions to hand them to any person who would give them a fair chance. I have no doubt of their success. I may say here that Mr. Tyrrell did all he could to make my work a success and in many ways helped me by advice and assistance.

Growth of vegetables is so rapid and vigorous that to a person coming from the east it is simply astounding. When I reached Dawson

on July 10, early cabbages were being cut and on August 5 their weight ranged from 3 to 5 lbs. On the 22nd, when I made my last visit, hundreds of matured cabbages and cauliflowers had been cut and sold. I measured the two lower leaves of a cabbage cut the day before and these placed opposite each other had an expansion of 3 feet 9 inches with a breadth of 16 inches. I cannot call this even an average one as there were hundreds larger, but later in maturing. Cauliflowers were from six to ten inches in diameter but I was told larger ones had been cut.

No doubt the constant daylight gives the force necessary to expand the growing organs of the vegetables in cultivation, but behind the long day are climatic conditions that as yet are little understood which in my opinion are the prevailing factor in this wonderful growth. Dr. Dawson in his geological report on this district indicated that there was little if any boulder clay on the Lower Pelly or Lewes rivers. Since then other reports have more than confirmed his statements, and my own observations tending that way have forced me to adopt new views regarding the past and present of the country.

Cause of glaciers.

One article of some eastern geologists' belief is that of an ice cap that covered the greater part of the American continent down to the 40th parallel. At Dawson in latitude 64° 15' and both north and south of it on the highest mountains there never has been glacier ice, yet the winter at present continues from early October to late April. Glaciers, no matter where they are found, are produced from one cause, which is greater deposition of snow than the sun has power to melt. As there is no evidence that glaciers have ever existed in this region, it follows that the snowfall has never been great. Mr. Stupart has kindly furnished me with an abstract of meteorological observations during the past three years and I find that there is an average of only nine inches of rain and sixty-five of snow each year. The cause of this light deposition was the next climatological factor and a study of the map of the Pacific coast revealed the undoubted cause.

Any one sailing from Vancouver to Skagway is soon aware after leaving Vancouver island, that there is a marked change taking place in the climate. After crossing Queen Charlotte sound, fog and rain are the prevailing characteristics in the summer, while in the winter they are snow, rain and fog. On the mountains over 5,000 feet, the deposition is chiefly snow. The snowfall being greater than the sun can melt descends toward the sea in valleys, often filling them to a great depth and taking the form of glaciers which descend to the sea. Passing north of Sitka, the tourist soon sees the immense glaciers that descend from the Mount St. Elias range. Here Mount Fairweather, 15,287 feet high, Mount Logan, 19,539 feet, and Mount St. Elias, 17,978 feet high

stand in plain view from the sea and the observer turns away with the certainty that a country whose sea border is nothing but ice and snow can be of little value so far north. Up to a very late date the whole Yukon valley has been considered of this character and the early explorers with their highly coloured accounts of their winter experiences tended to confirm it.

Effect of coast range on climate.

Instead of the coast range being an injury to the interior, it makes the climate pleasant both in summer and winter. The Yukon district has two climates, a wet and cold one on the coast which may be called the Alaskan climate as nearly all the coast region belongs to the United States. The climate of the Yukon district in Canada is just the reverse, being dry and warm in summer and cold in winter with a light snowfall. Owing to the moisture rising from the warm Japanese current being carried inland by the upper south-west air current and striking the coast range, this moisture is at once precipitated on the sea face of these mountains in the form of rain or snow and the air freed from its moisture descends on the Yukon plain as dry air and having an increased temperature. It follows that the rainfall must be light in summer and also the snowfall in winter. In another place I show that this is so from Mr. Stupart's report.

Light snow fall causes early spring.

The result of the light snowfall is an early spring in the whole Yukon valley including part of Alaska. Then the long day begins to assert itself and by the end of April, growth has commenced, and early in May the Yukon summer is fairly under way. So little rain falls in early spring that many residents asserted that irrigation was necessary to successful growth in certain localities. I do not believe in the necessity of this as the frost in the ground prevents the melted snow from penetrating the soil and keeps it near the surface. I can believe, however, in the necessity of irrigation if the gardener or farmer has waited a month after the snow is gone before sowing his seed. I have always recommended early sowing in northern regions, as growth always comes quickly after the snow has disappeared. The past season I saw oats that were sowed on June 5, that could have been sown a month earlier if the climate had been considered. All these matters will right themselves in time, but the climate must not be blamed for the ignorance of the cultivator.

Frost in ground beneficial.

Instead of the frost being an injury to the country it is a great benefit. A precipitation of twelve inches (snow and rain) means an arid climate and hence little growth. The severe frost being permanent or otherwise retains the moisture and from early spring to late summer the capillary attraction in the soil keeps the roots supplied with moisture and the constant daylight with an unclouded sun gives a vigour to vegetable

growth at Dawson that is never seen in the east. This constant growth brings all vegetables, berries and cereals to early perfection. It was with the utmost surprise that I found red currants and blueberries fully ripe on July 11 and many flowers with ripe seeds, and by the middle of August the trees and shrubs had perfected their wood and were ready for winter. Mr. Stupart's report on the Dawson climate, which is appended to this report, shows that on an average there is no frost from May 23 to August 23, or a period of 92 days, that the temperature rises to 70° or over for 46 days, or for half the period the temperature is 70° or over. Below I give a short table of the temperatures at Dawson and Ottawa for the months of May, June, July and August for the year 1900. The extract is taken from the Meteorological Report for 1902.

Table of temperatures from Meteorological report.

Ottawa, Lat. 45° 26′; Alt. 294 feet.

	Max.	Min.	Mean.
May	84·8	27·0	53·3
June	85·8	46·0	66·6
July	87·8	48·0	68·9
August	88·8	49·0	69·2

Winnipeg, Lat. 49° 53′; Alt. 760 feet.

	Max.	Min.	Mean.
May	91·5	14·0	57·3
June	100·5	33·0	66·3
July	86·2	41·0	64·9
August	88·2	45·0	67·4

Calgary, Lat. 51° 2′; Alt. 3,389 feet.

	Max.	Min.	Mean.
May	79·0	28·0	51·8
June	92·0	30·0	57·6
July	85·0	36·0	58·2
August	90·0	30·0	55·1

Dawson, Lat. 64° 15′; Alt. 1,200 feet.

	Max.	Min.	Mean.
May	67·3	22·7	46·6
June	87·6	36·4	57·2
July	85 9	41·1	61·1
August	81·3	30·0	53·1

The above are the four growing months everywhere in our climate and the most sceptical must admit that leaving out bright sunshine and length of day Dawson makes a wonderful showing. With these two factors added we are quite safe in predicting a great future for the Yukon district as a producer of everything needed to support a very large population.

With the facts learned last season and my former knowledge of the Peace River country, the Mackenzie River valley, and northern British Columbia, I am quite within the mark when I say that all the land having a suitable soil within this immense area will in the future produce enormous crops of all the cereals, wheat included. It is well within the memory of us all that growing wheat was for many years considered a doubtful matter at Edmonton and Little Slave lake. These points have passed the experimental stage and now good crops of wheat are secured every year. Two factors combine to make this success. The wheat itself is gradually conforming to its environment and ripening earlier, and local frosts are becoming rarer as the land comes more under the plough. The same changes will take place farther to the north and when wheat is grown as winter wheat and can start at once after the snow is off, it is hard to state how far this may be, at any rate as far as Dawson in latitude 64° 15' where we know there are three months without frost. A large grain producing area.

Mr. R. F. Stupart reports as follows on the climate of Dawson :—

CLIMATE OF DAWSON, YUKON.

A somewhat broken series of observations at Dawson and various other places in Yukon Territory between 1895 and 1898, and a continuous series at Dawson during the past three years, afford data for estimating with a fair degree of accuracy the average climatic conditions of the Klondike. The average annual mean temperature is about 22°; the mean of the three summer months is about 57°, July being 61°; and of three winter months—16°, with January—23.° Spring may be said to open towards the end of April, the last zero temperature of the winter usually occurring about the 5th of this month. May, with an average temperature of 44°, is by no means an unpleasant month and the 23rd is the average date of the last frost of spring. Daily observations during five summers indicate that on the average the temperature rises to 70° or higher on 46 days and to 80° or higher on 14 days; 90° was recorded in Dawson in June, 1899, and 95° in July of the same year. These temperatures with much bright sunshine and an absence of frost during three months, together with the long days of a latitude within a few degrees of the Arctic Circle amply account for the success so far achieved by market gardeners near Dawson in growing a large variety of garden produce including lettuce, radish, cabbage, cauliflower and potatoes, and warrant the belief that the hardier cereals might possibly be a successful crop both in parts of Yukon Territory and in the far northern districts of the Mackenzie River basin. August 23 would appear to be the average date of the first autumnal frost, the temperature rapidly declining towards the close of this month. Although night frosts are not infrequent in Average climatic conditions, Average date of autumn frost.

Winter temperatures.

September, the month as a whole is mild with a mean temperature of 42°. October may be fairly termed a winter month, the mean temperature being but 22°.5 and the first zero of winter recorded on the average about the 18th. Ice usually begins to run in the Yukon about the second week but it is not until quite the end of the month or early in November that the river is frozen fast. The temperature on the average during a winter falls to 20° below zero or lower on 72 days, to 40° below or lower on 21 days, to 50° below or lower on 7 days, and to 60° below or lower on 2 days. In January, 1896, 65° below was registered at Fort Constantine, and in January, 1901, 68° below was recorded at Dawson.

Observations of rain and snow have until the close of last summer been very fragmentary but it is probable that the summer rainfall near Dawson is usually between seven and nine inches, and that the total snowfall of the autumn and winter is between 50 and 60 inches.

Dawson well protected from winds.

Dawson being situated near the river with high hills or mountains on all sides is well protected from the winds, and a feature of the town and indeed of the neighbouring country is the long periods of calm weather which occur.

Geology of the West Coast of Vancouver Island.

Mr. Arthur Webster.

Field of operation.

In accordance with instructions received from Dr. Bell in June, 1902, to make a preliminary geological examination of the west coast of Vancouver Island, I beg to submit the following report of the work accomplished :—

Much difficulty was found in obtaining reliable information as to the best means of making the exploration. It was decided to employ Indians and their canoes, engaged from time to time from their numerous villages along the coast. This plan, after trial, was found to be impracticable, as only the old and useless men were left, the younger ones being away either sealing or fishing salmon for the Fraser river or other canneries. The few Indians remaining in the villages demanded exorbitant wages, and in any case were not to be relied on to work, except when hungry. I, therefore, considered it best to purchase a nineteen-foot sealing boat in Victoria and to do what was possible in it with Professor Haycock and one man. I may here say that I found the professor an able assistant, not only in regard to geological matters but for his skill in seamanship and willingness to help in every way.

The trend of the outer coast of Vancouver Island is northwesterly from Esquimalt harbour to Cape Scott. The shore is generally rocky, with a heavy surf usually breaking upon it, making it difficult and often dangerous to land on the exposed parts, but it is indented by many deep bays, arms and fiords, which, when once gained, afford excellent shelter. Much of the interior of the island has not, as far as I can learn, been explored even by the Indians, who seem to live entirely near the salt water and seldom venture inland.

Viewed from the shore line the interior of the island appears to be very much broken by deep valleys and steep ragged hills, many of the latter being snow-capped. The highest of these hills, however, does not exceed, I think, six thousand feet above the level of the sea. The direction of the ranges and valleys is usually roughly parallel to the shore line.

The coast, including the inlets and bays, was examined only along the shore line, no inland work of any extent having been done, the thickness of the undergrowth, consisting of 'sallal' bushes and ferns, as well as the quantity of fallen timber, causing much labour and loss of time for very little result. Where examined, the shore line was carefully worked out and will not, I think, require further investigation, but the work as a whole must be considered as only preliminary and the knowledge gained as but a foundation for future exploration. Examination confined to shore line.

In describing the geology I shall use the late Dr. G. M. Dawson's nomenclature as far as possible, which is described on pages 10 to 14 of his report for 1887. In this description the igneous dark-coloured trappean rocks with associated mica-schists, and gneisses, are said to be interbedded with argillites and crystalline limestones, classed as Triassic, on the evidence of the fossils discovered in the argillites, and named the Vancouver series. On the west coast of Vancouver island, however, we find the igneous rocks piercing and including fragments and masses of the crystalline limestones, just as the granites at and near their contact with the traps pierce and include the latter. Nowhere did I see clear evidence of the limestones being interbedded with the traps, though in many places at first view there is every appearance of their being so. I therefore look upon the limestones as being older and unconformable. Owing probably to the highly altered and crystalline character of the limestones, only a few very obscure fossils were found in them—not, I fear, sufficient to determine their age, but perhaps by more extensive research, enough might be discovered to throw light upon this point. The tracing of the boundaries of these various limestone bands is, I think, of importance, as almost invariably the deposits of iron and copper ores are found at or near the contact of the limestones with the igneous or volcanic rocks. Vancouver series.

Admiralty charts used.

In making the examination of the coast, the excellent charts issued under the direction of the Admiralty and the maps of the southern part of the island, procured from the provincial government, were used as a topographical base, rendering it unnecessary to make any surveys. The dips and strikes of the rocks and the bearings of the glacial striæ are given from the magnetic north, the variation being 23° east. The distances are stated in nautical miles.

Pedder bay and inlet.

The party left Victoria on June 20 for Pedder inlet, where work was commenced, the country between the two points having been already reported on by the late Drs. Selwyn and G. M. Dawson. Pedder bay and inlet are situated about nine miles south-west of Victoria city and the peninsula separating them from Becher bay to the westward forms the extreme south-eastern point of Vancouver Island, Race Rock lighthouse being on a rocky island a mile and a half to the southward.

From Parker bay, about three-quarters of a mile eastward of the Quarantine station at Williams head, round Quarantine cove to Pedder bay, including the point to Williams Head lighthouse and the east shore of Pedder bay and inlet to its head, the exposures of rock are nearly continuous and consist of dark-coloured hornblendic masses very compact and hard but generally much shattered with no evidence whatever of bedding. At Ashe point, near the head of the inlet, they become slightly schistose and at Reid's farm, half a mile further west, decidedly so. The lines of cleavage strike N. 65° W., mag. On Mount Mary, a hill 350 feet high, lying about one mile eastward from Farm point, the hornblendic traps are less shattered and show small veins of epidote. A small talus is seen on the south-westerly side of this hill, showing the direction of the glacial movement.

Large granite area.

From the head of Pedder inlet southerly, along the east shore as far as Shell point, these same rocks are met with, but they are much more shattered and are broken by numerous greenstone dykes. A large mass of granite and syenite occupies the higher ground and low hills of the peninsula between Pedder inlet and Becher bay. Just north of Shell point the granitoid rocks reach the shore and continue exposed from this point round Cape Calver to a quarter of a mile west of Argyle's farm, which lies on the main shore north-west of the westerly point of Bentick island. The eastern limits of this granitoid mass were not determined, but it appears to occupy the greater part of the interior of the peninsula, including North peak, Amy hill and Grouse hill. The greater portion of it is syenite, but it merges into diorite by imperceptible degrees. Bentick island and the smaller islands between it and the mainland are composed of the same rock.

At one-eighth of a mile west of Argyle's farm, we again come upon the fine-grained hornblendic rock of the Vancouver series. The actual contact of this with the syenite is not seen, the exposures being about fifty yards apart and the interval covered by drift. From this point westward all round Becher bay, the dark hornblendic rocks occupy the shore, varying somewhat, however, in that the crystals of hornblende are much larger about Aldridge point and at the 'Clallams' village in Campbells bay. Some prospecting for copper has been carried on along the shores of the bay but it has apparently been abandoned. Prospecting done.

All the islands in the bay are formed of the more or less massive hornblendic rocks of the same series. On Fraser island, the measures are very fine-grained and almost black. Exposures of the same dark hornblendic rock are seen all the way round from Murder bay to the north-east corner of Becher bay and easterly to the head of Pedder inlet.

From Cape Aldrich westward and northward, round Beechey head to the entrance of Sooke harbour at East Sooke post office, the rocks are of the same (Vancouver) series, showing no evidence of stratification. Two old abandoned openings are to be seen a short distance inland from Company point. Little work had been done, however. These prospects are in magnetic iron ore, of which there may be a considerable body, but the ore is much charged at the surface with iron and copper pyrites, and some pyrrhotite. Cape Aldrich to Sooke harbour.

Sooke harbour is entered by a narrow crooked channel, owing to a sand spit nearly closing its mouth, and might be easily passed by one not knowing the coast. In bad weather from the west, a heavy sea breaks at the mouth, especially if tide and wind meet. Once the harbour is gained, however, there is a large expanse of deep water and good shelter.

From West Sooke post office, following the northerly shore of the harbour eastward, no rock exposures are seen till we reach Coopers cove, towards the north-east side of the harbour. Here upon a narrow peninsula running eastward nearly across the mouth of the cove, occurs a cemented conglomerate, composed chiefly of beach pebbles and coarse sand holding small disconnected beds or patches of lignite. Inside the cove and at its north end dark green fine-grained hornblendic rock very compact and without any sign of stratification is seen.

On section 63 on the east side of Coopers cove there is a band eight feet wide of highly altered, somewhat shaly, argillaceous rock, interbedded with the harder and more compact greenstone, the contact on both sides being plainly visible. This band strikes N. 60° E., mag. and dips to the westward at an angle of 60°. On section 60 of Coopers cove.

Coopers cove, the same argillites are seen, having a thickness of 15 feet and dipping also to the westward, being separated from the former by 500 feet of dark green igneous rock, which weathers on the surface to rounded masses, like concretions. On section 57 on the east side of the mouth of Coopers cove, another exposure of the stratified rocks occurs, with the same dip and strike as before and separated by the dark green hornblendic rock in the same manner as the others. In the last two exposures the argillites appear to gradually merge into the dark green massive rock, no clear line of demarcation being seen.

Argillites.

From this point the stratified argillites appear in several places as far as the mouth of the small brook on sections 59-70, separated by and interstratified with the trappean rocks. The latter however, here, show a decided basaltic character.

Basalt.

From this locality southward, round the head of Sooke harbour to section 110, greenstones, some of which are of a basaltic character, line the shore. At the mouth of a brook in the south-east corner of Sooke harbour, gray basaltic rocks are met with, cut by numerous porphyry dykes and holding small veins with stringers of epidote. From this locality to section 98, including Anderson cove, only the dark massive igneous rocks are met with, showing little or no variation in character. These igneous rocks of the Vancouver series are seen westward along the south shore of the harbour as far as East Sooke post office. At Cartwrights, on section 97, traces of native copper are found in the hornblendic rock, adjoining a porphyritic dyke. These dark rocks extend southward across the post road, running between Victoria and East Sooke post office.

Mount Maguin.

Mount Maguin, lying to the south of sections 98-110, occupies a considerable area and is composed of syenite or diorite. At and near the junction of the syenite and igneous rocks there is what appears to be an extensive deposit of copper ore, chiefly chalcopyrite but mixed with some magnetic iron. A shaft, thirty feet deep, had been sunk and work was still going on with a small force of men on the 1st of July. The ore occurs in a hornblendic gangue and is said to assay well. The prospect is well situated for shipping, having a fair grade to deep water. The work was not sufficiently advanced to form any reliable estimate of the extent of the deposit. About 150 feet north of the copper deposit, a peculiar granitoid rock appears, consisting of large crystals of light-coloured, almost white feldspar, and dark grayish green hornblende. This outcrop is of small extent and could be traced for only a few hundred feet.

Cape Sherringham.

At Cape Sherringham and for a mile to the eastward towards the mouth of Sooke harbour, the rocks consist of hard massive greenstone,

holding epidote in veins and patches. In the breaks between the exposures of trap there occurs a sandy conglomerate, holding angular and rounded fragments of the same greenstone. Some of the embedded masses show striæ; but the glacial action may have been prior to the conglomerate formation, the trap itself showing glacial striæ running S. 75° W. At the mouth of Coal creek, one mile and a half east of Sherringham point, large exposures of sandstone are seen, holding vast quantities of fossil shells of various species of which a sufficient collection was made to enable the horizon of these beds to be defined. These sandstones lie nearly flat, dipping at a small angle to the westward. The sandstones are seen resting on the trap just eastward of Sherringham point. An ascending section gives the following:— Section.

	Feet.
Moderately hard gray sandstone..........	10
Sandstone shell beds with traces of lignite....	6
Soft sandstone with concretions.............	12
Friable sandstone........................	10
Loose earth and loam.....................	8
	46

A portion of the lower bed is covered by the sea, so that its thickness was not determined.

From half a mile west of Muir creek to the mouth of Coal creek there are extensive exposures of these sandstones, more or less fossiliferous and holding lignite, the actual contact with the traps not, however, being seen. The traps are partially basaltic. Muir creek.

At Otter point basaltic greenstones also occur.

Along the north-east shore of Sooke bay, half a mile from the entrance to Sooke harbour, banks, 60 to 70 feet high are seen, consisting of boulder clay, holding striated pebbles and boulders, and underlaid by coarse conglomerate. A few remains of vegetable matter are seen in the clays. On section 16, Sooke bay, the following descending section of these clays and sandstones occurs:— Section on Sooke bay.

	Feet.
Boulder clay.............................	15
Soft sandstones and gravel with concretions of sandstones..........................	20
Friable sandstones........................	14
Sand and small pebbles loosely cemented.....	12
Conglomerate............................	2
	63

The thickness of the lower bed of conglomerate was not determined. The conglomerate is partly cemented by oxide of iron.

The following ascending section of these sandstones occurs on section 6, Sooke bay:—

	Feet.
Beach at high water.	
Hard bedded sandstones, beds 6 inches thick.	4
Conglomerates (beach pebbles)	6
Soft friable sandstone.....................	10
Boulder clay	20
	40

Section of bore-hole.

A section given by a bore-hole put down on the west side of the sand strip at the mouth of Sooke harbour, by Dr. C. Forbes in 1863, is stated to be as follows in descending order:—

	Feet.	Inches.
Drift..........................	?	
Clay and sand.........	?	
Conglomerate	4	0
Red sandstone...............	12	0
Gray sandstone..................	15	0
Till (shale)?....	8	0
Coal	0	6
Shale...................... ...	2	6
Fire clay........................	2	6
Till.............................	6	0
Kringle...	1	0
Red sandstone....................	3	0
Coal	1	0
Shale and fire clay.................	18	0
Gray sandstone.....	2	0
Kringle	1	0
Till	6	0
	82	6

Sherringham cape to Providence cove.

From Sherringham point to Providence cove, the measures were not examined, the distance along the coast being 22 miles, but only seen from the steamer 'Queen City' on its way to St. Juan port. After leaving Sherringham point, they appear to consist of a dark coloured mica schist of the same character as those at Providence cove. The eastern boundary of these schists was not determined, but is probably at or near the mouth of Jordan river.

Providence cove lies about three miles east of Cape St. Juan, which forms the south-east point of Port St. Juan. The rocks here consist of mica schists of rather coarser texture than those to the westward. They are so folded and twisted that it is impossible to distinguish bedding from cleavage, but the general strike appears to be from N. 10° E. to N. 60° E., with a westerly dip at an angle of from 10° to 40°. At several points beginning about one mile west of Providence cove and extending to Minnesota point, which is about one-third of a mile east of Cape St. Juan these slates or schists are overlaid unconformably by conglomerates and friable sandstones, notably at Minnesota point, where they have a thickness of forty feet. These sandstones resemble those of Coal and Muir creeks, and the lower beds contain a few obscure fossils, chiefly corals.

At Cape St. Juan and on Observatory island, just off it, the slates and schists are well seen, but so broken, twisted and altered by intrusive trap dykes, (some of which run with the strike, having offshoots cutting the slates at right angles) that no estimate of the thickness could be satisfactorily made. The general strike of the slate beds is north-east and south-west, with a westerly dip of from 10° to 45°. Both sides of Port St. Juan are formed by mica-slates or schists, very much broken and contorted by trap dykes which cut them in all directions. The shores on the west side rise abruptly from the water's edge and are worn into many curious forms from the erosion of the heavy surf which continually beats upon them. The valley of the St. Juan river falls in from the eastward, forming a low delta which extends some distance inland. An island of considerable extent lies at its mouth, nearly closing the southern passage by a sand bar, the main channel flowing into the harbour on its north side.

Port St. Juan.

The slates and schists of the St. Juan, extend up the Gordon river, which joins the former about half a mile from its mouth. For some two and a half miles they are much bent and twisted by numerous trap dykes. The strike is from north and south to south sixty degrees west, the dip being to the westward at all angles from 10° to 90°. These are followed to the northward by a dark greenish diorite which shows itself for nearly half a mile About a mile from Newton's camp, or some five miles on the trail from the mouth of the Gordon river, a band of highly crystalline limestone occurs, forty feet in thickness, followed by diorite, the northern boundary of which was not determined. Mount Edinburgh, lying N. 15° E. mag. from Newton's camp, is said to be of limestone.

Gordon river.

The Newton mine, which is on the Gordon river about six miles from its mouth, is in magnetic iron ore with a good surface showing, but it has some traces of iron pyrites. A good deal of work has been

Newton mine.

done here. A shaft nearly 300 feet deep has been sunk, and at this depth it is proposed to drive a cross-cut to tap the ore. About 14 hands are employed, but as yet, no ore has been shipped. The timber along the Gordon river is generally good and consists chiefly of spruce, hemlock and balsam. One spruce tree 5 feet 2 inches in diameter at twenty feet from the ground had 285 well marked rings of growth.

Owen point to Cape Beale.

At Owen point, on the north-west side of Port St. Juan, the mica schists are seen overlaid unconformably by sandstones similar to those seen between Providence cove and Minnesota point. The sandstones lie nearly flat and continue for some miles towards Carmanah.

Owing to bad weather and westerly winds, a stretch of about thirty miles of coast between Owen point and Cape Beale could not be examined, but it is probably occupied as far as Nitinat by the St Juan mica-schists of the Vancouver series.

In the bay upon the main shore, 200 yards west of the head of Bamfield creek, fine-grained, dark trappean rocks are exposed, having a slight conchoidal fracture, cut by masses of intrusive syenite and gray diorite containing a very small proportion of biotite. The greater part of the diorite has a grayish appearance, but one band is of a reddish colour. The ridges run about N. 75° W. mag.

The islands to the westward of this bay were not examined, but they seem to be formed of similar rocks. From this bay to the south and eastward, towards Cape Beale, as far as Sandy bay, only fine-grained traps were seen and they are not cut by any intrusive dykes. Upon the trail towards Cape Beale and about one mile and a half south from the head of Bamfield creek occurs a band of fine-grained gray diorite which is seen as far as the Long beach, and here the diorite cuts the traps of the Vancouver series. On Long beach black magnetic sand is found exposed in beds of one-sixth to one-half inch thick on the lee side of a mass of rock. No colours of gold were observed and the deposit is of no importance. Diorite, both of light and darker coloured varieties, extends from this point to Cape Beale.

At Cape Beale lighthouse, which stands 130 feet above sea-level, upon an island separated from the mainland by a narrow channel which is almost dry at low tide, the rock is of coarser grain and lighter colour, much resembling a granite. There is no evidence of glacial action.

Cape Beale lighthouse.

The exposures on Bamfield creek consist of fine-grained hornblendic trap-rock like that cut by the diorites to the south of it. From the mouth of Bamfield creek north-eastward up the easterly shore of the Alberni canal to Dixons island and point only grayish

diorites are met with. Here a fine-grained crystalline limestone shows itself, striking south 50° to 60° E. and dipping south-westerly at an angle of 50°. The stratification is very apparent, the beds being from 5 to 7 inches thick and the band probably 200 feet thick.

The south-west point of Poett cove is of fine-grained greenish trap. About a hundred yards further into the cove there is crystalline limestone, apparently interbedded with the trap-rock, striking north and south and dipping westerly at an angle of 40° to 50°.

Limestones.

Limestone also occupies the north-east side of the entrance of this cove, striking S. 20° W., dipping westerly at an angle of 35° and seen for half a mile into Numukamis bay, succeeded by light-coloured dioritic beds. Crystalline limestone is again seen on the south-east end of Santa Maria island and on a small island just off it, while on the north end gray granitic rock is met with. At the south end there are traces of magnetic iron ore in what would seem to be a dyke which breaks up and shatters the adjoining rocks.

Sarita river.

The Sarita river falls into the Alberni canal from the eastward, about half-way up Numukamis bay, forming a flat at its mouth about three-quarters of a mile wide, its valley being bordered by low hills on either side. An iron deposit, associated with limestone, occurs a few miles from its mouth. On a small island opposite the mouth of this river, a porphyritic rock is seen, which is probably intrusive. At the point on the north-eastern shore, near the small Indian village, is a much jointed and broken greenstone, resembling that seen on the south end of Santa Maria island. A highly altered chert-rock occurs in the small bay about one mile north-east of the mouth of Sarita river. These rocks are also seen on Congress island, rather less altered and having an obscure bedding. The stratification would appear to be horizontal, but it is much disturbed by trap dykes.

San Mateo bay.

Fine-grained greenstone forms the point of land separating Numukamis from San Mateo bay, but at Cherry point on the north-east side of the bay, granitoid rock appears for about half a mile. Diorites or granites are seen alternately from this point, as far as Coleman creek, the granitoid rock being rather in excess of the trap. From Coleman creek northward to opposite the mouth of Nahmint river rocks of the same character occur, except that perhaps greenstone predominates.

Hills in the interior probably granite.

From this point to within half a mile south of the mouth of China creek, exposures of a grayish granite are almost continuous. From the shapes and slopes of the hills in the interior, I would judge them to be also granite. From China creek northward through the second narrows to the head of the canal at Stamp harbour, the rock is all

dark greenish trap of the Vancouver series, as is also the west side of the canal from its head to opposite Mount Hankin where an obscure strike was observed, south 5° east; dip westerly at an angle of 25°.

From half a mile south of Coos creek, where a small stream comes in from the westward, grayish granite, composed of hornblende and feldspar with but little free quartz, is exposed almost the entire way to the north side of the mouth of Nahmint river. Thence as far as the ore bunkers of the Monitor mine, about half a mile north of the mouth of Green creek, greenish fine-grained trap is almost continuous.

Uchucklesit harbour.

From Green creek along the north shore of Uchucklesit harbour, bands of crystalline limestone and fine-grained trap, which at first sight would appear to be interbedded, are met with; but in a small bay two-thirds of a mile to the south-west of the Monitor bunkers, the hornblendic rocks are certainly intrusive, cutting and including fragments and masses of the limestones. The limestone on the small island, at the mouth of Uchucklesit harbour, strikes N. 50° E.; dip easterly at an angle of 25° to 45°.

The limestones are as much altered in the middle of the bands as at the contact with the traps and are so folded and contorted that a very close survey would be required to make even an approximate section.

Copper.

At the Happy John claim, a copper prospect adjoining to the westward the Monitor mine, the contact shows without question that here the limestone is the older rock, the trap inclosing fragments and masses of the limestone.

The west side of Uchucklesit harbour, the south-westerly point and the shores of Rainy bay and Useless inlet are of hard compact hornblendic rock, marked by epidote in small veins and stringers. At the south-east point of the entrance of Rainy bay, a small band of amygdaloid is met with. Owing to heavy weather we were unable to get out of the south-west entrance of Useless inlet and were obliged to return round the north end of Seddall island to the small harbour of Ecole on its south-east side and opposite the north end of Copper island, where we remained a day to dry out provisions and blankets.

Ecole harbour.

The rock on the north side of Ecole harbour and extending for a mile or more to the westward, is white crystalline limestone, much cut by traps, confirming the view that the limestone is the older rock and that the traps are intrusive, at least in certain localities. Mr. Haycock found here traces of obscure fossil remains. The rock on the easterly side of Seddall island is all dark, fine-grained trap.

On the north-east end of Copper island and down the east shore as far as Clifton bay, crystalline limestones, intimately associated with traps, strike south 40° west. These limestones cross the middle of Copper island and can be traced as far as Marble cove on its westerly side. On Copper island, a short distance inland and seven hundred feet above sea-level, the Pacific Steel company of Ironside, Wash., U.S.A., are opening up an iron claim. The ore is magnetic iron of good quality and said to assay 60 per cent metallic iron. A tunnel has been driven two hundred and two feet following the ore, which shows a width of about one hundred feet near the limestone and trap contact and extends to the top of the hill, one hundred feet above the sea. The mine has good facilities for shipping, as there are sixty fathoms of water in the cove. Copper island.

Limestone is reported to occur a short distance up the Sarita river, at another iron property belonging to this company. The small islands between Copper island and the eastern main shore are of fine-grained dense hornblendic rock. So far as observed, the limestone, when in large bands invariably rests on the trap of the Vancouver series.

The shores between Useless inlet and Clayoquot were not examined, owing to bad weather and a desire to take the steamer to the latter point. White crystalline limestone is said to have been quarried for marble in Effingham inlet. Useless inlet and Clayoquot sound.

Clayoquot store and post office are situated on a small island in Broken channel, lying about half-way between Vargas and Meares islands. The formation here is a very fine-grained dark hornblendic rock, having the general appearance of a trap, but in places showing obscure bedding.

The southern part of Round island, lying a mile east of Clayoquot post office, consists of gray granite, the north half being of a very dark fine-grained hornblendic rock, weathering almost black. Being cut by dykes, the actual contact of these rocks with the granites is not evident, but the line of general contact strikes about N. 70° W. The same dark-coloured hornblendic rock is seen on the main land at the low point east of Round island. These rocks are again seen on a small island at the entrance to Brownings passage. Here they show a slight slaty cleavage and are exposed as far as the narrows in Brownings passage, where on a small island, gray micaceous hornblendic granite is met with. Round island.

At the east end of Meares island, granites occur in large masses along Indian island; they appear to be more hornblendic, carry less mica and are of a darker colour. Here mica-slates, striking from N. Meares island.

40° to 60° W., dip easterly, at an angle of 85°, much resemble gneisses and contain a good deal of free quartz, running parallel to the bedding and cleavage. Many of the layers weather to a whitish or a drab colour. The fracture is dark gray with dark-coloured mica on the cleavage faces. The thickness of these slates is probably about 1,600 feet.

Indian island. The easterly end of Indian island and the point of the mainland opposite consists of dark gray granite, extending for some distance inland. Crossing eastward to the mainland, these granites continue for a mile into the bay, bearing N. 8° E. from the east end of Indian island, and are followed by gneissic rocks, striking N. 70° W., to within a mile of the mouth of Kennedy river, where dark hornblende granite occurs and extends half a mile up the river, when white crystalline limestone was noticed as far as the head of the rapid. From the rapids, up the river to the lake, the shores are low and swampy, showing no exposures of rock. A small salmon cannery is in operation at the mouth of the river.

Kennedy lake. Kennedy lake, of which this river is the outlet, is a considerable sheet of fresh water lying to the north of Wreck bay and east of Tofino inlet and separated on the south from the ocean by several miles of low-lying sands. The surrounding country is covered by a scrubby growth, chiefly of spruce, and the lake is fed by the Elk river, which falls into its north-east arm. Going round the shores, dark-weathering, very hard, hornblendic rock and white crystalline limestone are seen at the point north of a deep bay on the south side of the lake. This has beds or rather bands of a darker coloured hard character which are not so much affected by weathering as the softer ones. The strike is north 45° west; dip south-westerly at an angle of 50°. I was not able to determine its thickness.

Limestone. Hornblendic rock, cut by several trap dykes succeeds the limestones. At the extremity of the point of South bay is a fine-grained amygdaloid marked by epidote. Greenish-gray hornblendic rocks occupy the south-east side of South bay as far as a small stream from the south. Crystalline limestones, cut by greenstone dykes, compose the south-east shore as far as the south side of a small bay, bearing S. 10° E. mag. from Long island. Another exposure of limestone, striking S. 20° E. and cut by an 8-feet dyke, is seen in a small bay east from the south end of Long island.

Elk river. North-eastward of this island, Long point runs out to the north-westward. This consists of a dark-greenish fine-grained trap, very compact and holding feldspar and epidote. Rocky island, half a mile north-west of the point, is composed of the same kind of rock, as

is also the western side of the north-east arm, as far as the mouth of a small stream falling in from the north. The rock on both sides of the narrows towards the mouth of Elk river is light-coloured hornblende granite, holding free quartz. This is followed northward by greenish trap, holding epidote, of the same character as that on Long point. A small exposure of limestone is seen at the mouth of Elk river. The river is not shown correctly on the chart.

Elk river.

Mount Maitland, to the eastward, appears through the glass to be capped by limestone. Several prospects lie some few miles up Elk river, one, the 'Rose Marie,' having free gold in quartz. From the narrows, southward along the west side of the point, towards the outlet a massive fine-grained hornblendic rock prevails for three-fourths of a mile. Then a small exposure of crystalline limestone is seen resting on this rock. The east shore of the western arm of the lake, Agnes island and the point south of it, consist of a coarse-grained hornblende granite. The rock seen on both sides of the narrows is a dark-weathering whitish-gray granite, followed towards the head of the arm, by a dark greenish coloured trappean rock which weathers much like a granite. Half a mile from the head of the inlet, which is wrongly shown on the map, there is a small exposure of crystalline limestone, striking S. 20° E. and dipping easterly at an angle of 40°, cut by intrusive greenish trap. The point on the west side of the entrance to this arm is composed of a greenish hornblendic rock, probably diorite. At the cannery on the right bank of Kennedy river a knob of gray granite is met with.

Kennedy river and Tofino inlet.

On the long point jutting out from the mouth of Kennedy river, forming the south-eastern entrance to Tofino inlet, there occurs a gneissic rock, which strikes S. 80° E. and dips easterly at an angle of 35°. The east shore of Tofino inlet, with the exception of a small exposure of crystalline limestone, is gray, coarse-grained granite. The limestone occurs again about one mile south from Deer river. At one-eighth of a mile from the mouth of Deer river, a gray schistose rock replaces the granite. The beds here would appear to be a highly altered and contorted sedimentary rock. Greenish fine-grained trap is seen at the mouth of Deer river. On the west shore, for two miles south from the head, the Vancouver series is represented by igneous hornblendic rock, after which gray schistose measures are met with, consisting of rather coarse-grained gneissic rock containing quartz, feldspar, mica and hornblende.

A very small patch of white crystalline limestone, associated with greenish igneous rock, is seen on a small island just north of Woman island. Coarse gray granites and granitoid rocks form the long point stretching southward between Tranquil creek and Tofino inlet.

Tranquil creek.

Limestone occurs on the west shore at the mouth of Tranquil creek, having a width of 150 yards, and striking from S. 60° W. to east and west. Gray granite lies on both sides of it. From this locality southerly to the main point north of Warne island, nothing but coarse gray granite is seen.

The north end of Warne island is granitoid rock, consisting of veins of true granite with quartzite and dark hornblendic zones. Mica-schists or micaceous gneiss, striking N. 20° W. and dipping at an angle of 60° occur at the most southerly part of the point, turning into Deception passage; probably a continuation of those seen on Indian island. Close to the entranee of Fortune channel, dark hornblendic rock, slightly schistose in places but chiefly massive, is seen and gray granites occupy the west shore from the entrance to a point opposite Race narrows.

Warne bay.

Compact trap, marked by epidotic nodules, and gashes occupies both sides and the head of Warne bay. The face of the most southern part of the north shore in Race narrows is white crystalline limestone, with a marble-like fracture, weathering to an ochreous yellow. Towards the western point, the limestones assume a schistose character and strike N. 40° to 50° W.; dip. N.E. at an angle of 30°. These are succeeded at the point leading into Bedwell sound by greenish trap.

Bedwell sound.

Leaving the limestone, which is much twisted and contorted by intruding trap on the east shore, opposite Fern point, nothing is seen in Bedwell sound but the igneous rocks of the Vancouver series which occur at one point on the west shore about half way to the head of the sound; then a small band of cherty bedded rock is seen for 400 yards, striking north 30° west and dipping westerly at an angle of 20° to 40°. The sound has high rocky banks, alternating with short beaches.

Cypress bay.

From Turn point, running to the southward between Bedwell sound and Cypress bay, high rocky and bare bluffs show themselves. They are composed of dark and rather compact trap. Just round the point and opposite some small islands in Cypress bay, a bedded cherty rock appears, resembling that seen in Bedwell sound. This continues round Cypress bay to Calm creek. From this creek to Trout river, which falls into Cypress bay the ordinary traps are met with. The point on the left bank of Trout river at its mouth, is a dark diorite, very compact and weathering to a spotted white and green surface. With the exception of a small vein of calcareous rock, associated with traces of yellow copper ore, seen in a small bay south of the mouth of Trout river, nothing but the trap was noticed around the Cat-faced mountains as far as Bawden bay, near the entrance of Herbert arm. These rocks continue round Charles point, at the en-

trance to Herbert arm, occasionally becoming schistose and all of them being marked by epidote in stringers and nodules. Three-quarters of a mile east of Charles Point, towards White pine cove there is a dark-weathering crystalline limestone, having harder and somewhat siliceous bands. The strike is S. 40° E.; dip very irregular but generally to the south-westward at angles of from 30° to 60°.

The islands north of this exposure show bands of cherty white limestone, highly crystalline and apparently interbedded with the trap. From these islands the rock around White Pine cove is green, heavy trap, much marked by epidote. Just beyond the north point of the cove, yellow-weathering limestone is seen, in a narrow band, having trap on either side. Its strike is S. 10° W.; dip easterly at an angle of 50°. This band follows the shore for several hundred yards and is somewhat slaty in structure. It is followed to the north by green hornblendic rocks to within a mile of the head of the arm, when a small exposure of crystalline limestone is seen, striking N. 20° E.; dip eastward at an angle of 45°. The head of the arm is bounded northerly and easterly by high rocky mountains with steep sides and pointed, jagged crests. Small exposures of limestone occur at several points along the west shore, intimately associated with fine-grained dark trap. On the southern part of a long point, there is a bed of trappean agglomerate in which the surfaces of the balls or nodules are apparently fused together at their contact with one another. This bed stands out of the water about ten feet and is overlaid and flanked on either side by massive trap. The exposure is about fifty feet wide. Across the bay south of this point there is a small exposure of crystalline limestone, striking S. 20° W. and dipping westerly. This seems to underlie stratified gneissic rock with the same dip and strike for a short distance. Then maintaining the same dip and strike it is found for a short distance overlying rocks of the same character.

White Pine cove.

Limestones.

From this locality going round into North arm to a point half a mile south of the Indian village of 'Alelyon,' nothing is seen but massive hornblendic rock. Here a stratified quartzite, weathering brownish-yellow and holding quantities of small cubes of iron pyrites is seen striking N. 70° E., with a northerly dip of 50° From the village, dark gray hornblendic granite extends to one mile south of the eastern entrance to Shelter arm; here on a small island a thirty-feet band of crystalline limestone appears, striking east and west. The contact of clearly intrusive granitoid rocks is seen on both sides of it. From this, for half a mile into the narrows, on the east side of Obstruction island, occurs coarse-grained trap, having a slight tendency to become schistose.

Shelter arm.

The northern point of the narrows consists of a massive granite, the small island just off this point being also granite of a gray colour, holding much free quartz. These granites extend round the point, where the contact with the dark green trap is plainly seen, the granites being certainly the newer and intrusive rock, forming small dykes which enter the trap and inclose many fragments of the latter, their edges being sharp and distinct. The green trap extends round the bay to the narrows at the head of the arm. This is slightly schistose in spots, but more massive at a distance from the granite. Granite and granitoid rock form both sides of the arm at its head, rising in high precipitous cliffs, especially on the west side. The hills appear to be glaciated for at least 2,000 feet in altitude.

Glaciated cliffs.

On the north-west shore of Shelter arm, from the narrows as far as the stream and beach, north of Obstruction island, with the exception of a small patch of crystalline limestone, the rocks consist of diorites cut by intrusive granites, inclosing masses of the older rock. From this stream to a deep bay, north of the long point running eastward towards Obstruction island, nothing is met with but dark green fine-grained greenstone, holding less epidote than usual. At the point itself and along the shore thence westerly and along both sides of Sydney inlet to within three and a half miles of Sharp point and Refuge cove (at the south-west entrance to the inlet), only granitoid rocks are seen. They often resemble gray diorite and hold a small percentage of mica.

Flores island.

On the north-east and north-west sides of Flores island, including Steamer cove and Rocky passage, and south to within two and one-half miles from the mouth of Matilda creek, gray fine-grained granites are met with. Thence southward, including Matilda creek and the shore past Ahousat village, on to White Sand bay, only greenstones of the Vancouver series are exposed.

Cone island.

Cone island lies in the middle of the North Arm channel, about two and a half miles west of north from Ahousat village. The hill predominating this island is in the form of a nearly perfect cone formed of granite and rising about 1,000 feet above the sea. On the south-west side of the island, half a mile north from the south-west point, gneissic rocks of no great extent are found striking east and west and dipping northerly at an angle of 45°. The north-west corner of the island is formed of a fine-grained gray hornblende granite.

Coal measures, with some coal in sight, are said to occur at Rafael point on the south-west corner of Flores island. We were unable, however, to make an examination of that part of the island.

Friendly cove in Nootka sound was reached by the steamer *Queen City* on August 23. From Burdwood point, eastward from Friendly cove, gray granite extends for a mile to the north-eastward and as far southward as Escalante point, but it was traced no farther. These granites are succeeded to the eastward, between Mounts Banke and Adair, in the Zuciarte channel, by trap, which, in spots, assumes a basaltic form. Granite, which appears to be intrusive, is seen for half a mile in the bay under Mills mountain. This is followed by dark trap rock, much broken, which, west of Mount Sergeant, becomes slightly schistose, and continues to within a short distance of Point Anderson, itself composed of granitoid rock cutting trap. On the north-east side of this point, a small band of calcareous character strikes N. 10° E. and dips westerly at an angle of 45°. This band is seen for a short distance along the west side of Camp bay. Nootka sound.

The easterly side of Camp bay and eastward for half a mile is composed of greenish trap. Gray granite, holding hornblende and mica extends thence with but little interruption for about seven miles and a half up Muchalat arm. At a small brook, about eight miles east of Camp cove, where crystalline limestone occurs, cut and broken, in many places, by both granite and greenstone dykes, the strike of the limestone is S. 70° E; dip southerly at an angle of 45°. From this exposure of limestone to the cannery at the stream and beach south of a small island in mid-channel, granite and granitoid rock holding fragments of the Vancouver series were observed. From this point, gray granite and dark hornblendic rock alternate round the point of, and for half a mile into the southerly extension of the arm where a band of crystalline limestone about 250 yards in extent occurs. This band is not so highly crystalline as is usual with these limestones, but no traces of fossils were discovered. It strikes N. 60° W. and dips south-westward at an angle of 30°. It is probably the same band as that seen two miles west of the cannery. The westerly side of the southerly end of this arm consists of gray granite. Muchalat arm.

Along the east shore of this arm, from the head as far as the mouth of Gold river, rocks of the Vancouver series are seen continuously. They consist chiefly of fine-grained, dark greenstones, holding very small cubes of iron pyrites and a few small, scattered garnets with epidote. Opposite the point on the west shore of the main arm there occurs a small exposure of amygdaloid. At the mouth of Gold river there is a small Indian village of a few huts. Tradition says that the Spaniards, when occupying the fort and trading post at Friendly cove found gold in this river and worked the gravels. Trap extends from the point on the west side of the river for a quarter of a mile. Gravels of Gold river said to have been worked for gold.

Gray granite with an occasional small exposure of trap forms the whole north shore of Muchalat arm to the point turning northward into Tlupana arm, including Gore island, which is all gray granite. The granites when in contact with the trap rocks inclose and surround fragments of trap so plentifully in places as to make it difficult to define the dividing line within several hundred feet. The fragments of trap inclosed vary in size from a few inches to several cubic feet, and their edges and angles are but little worn.

Tlupana inlet.

The granitoid rocks continue along the east shore of Tlupana inlet and form the southerly part of Separation saddle. At the northerly narrows on the west side they appear in very abrupt bluffs, covered by moss and bearing a few scattered firs and spruces. On the north-west side very white fine-grained crystalline limestone is cut by many intrusive dykes of dark trappean rock. Its strike is S. 20°E; dip easterly at an angle of 40°. These limestones are seen as far as the stream and beach at the head of North-east bay. Following the north side of the bay, fine-grained dark hornblendic rocks are met with for a mile from the head of the bay to a point opposite a small island. Bands of white crystalline limestone are seen here, both on the main shore and on the islands. The band upon the main shore is seen for some 200 yards. The strike is very uncertain, varying apparently from N. 30° W. to east and west and the dip is northerly at all angles from 5 to 50°.

Limestones cut by trap dykes.

These limestones are followed for a mile south, on the west shore, by fine-grained hornblendic rock. Gray granite is seen on the west shore for a little over half a mile and is succeeded, opposite the south-west end of Separation saddle, by crystalline limestone, cut and broken and so thrown about by intrusions of greenstone that no dip or strike can be indicated. These limestones are seen for nearly a mile, or to the point turning south-west along Tlupana arm. From this point south-westerly and up half-way to the head of Deserted creek, gray granite and granitoid rocks are met with. Limestones are seen around the head of Deserted creek from this point to a place on the south-west shore, nearly two miles from its head. These limestones are much cut by trap dykes; the general strike is, however, south 80° west. They are succeeded by a gray granite, inclosing fragments of a darker rock (some of which appear to be partially flattened) to within a mile of the north-east entrance of Tahsis canal to the north of Canal island.

The north half of Bligh island and its eastern side, including the long peninsula between Ewin creek and the Zuciarte channel is composed of the ordinary gray granite. The south-westerly half, including the islands lying between it and Nootka island, are of green hornblendic rocks of the Vancouver series, much cut by granitic dykes.

From Friendly cove (Yuquot village), for two miles north, dark hornblendic rocks occur, which may be highly altered sediments, but having a bedding so very obscure that it cannot be distinguished with certainty. To the northward of these follow, on the west shore, gray granite and granitoid rocks, which include Narrow island at the mouth of Tahsis canal as far as two miles south of Tahsis narrows, which lead westerly to Hecate channel and Esperanza inlet.

Dark traps of Vancouver series.

On the eastern side of Tahsis canal as far as the north end of Narrow island, the measures are concealed, but they are probably the Vancouver series. From this locality northward for three miles, granite and granitoid rocks are seen. Thence to the head of the canal, a distance of about ten miles, rock of the Vancouver series is exposed, consisting chiefly of dark traps. A small exposure of limestone occurs half a mile beyond the second narrows on the east shore.

This limestone is succeeded to the northward by an exposure of agglomerate, dark in colour and consisting of rounded masses of from one to six inches in diameter. This is followed by crystalline limestone, which is seen along the shore for two miles, striking S. 60° E. to S. 80° E. and rising in bluffs 200 feet high at 300 feet from the shore. These limestones are very much cut up and thrown about by the usual intrusive hornblendic rock, which is seen in several places completely surrounding fragments of limestone several feet in length. No fossils rewarded a diligent search. The limestones are followed by traps for half a mile. The latter are succeeded to the northward by crystalline limestone, as far as the beach, a mile from the head of the canal. Dark green hornblendic rock is seen on the east shore near the head of the bay.

Tahsi narrows.

On the west shore for a mile and a half, crystalline limestone again occurs, striking S. 60° S. or E., mag., and is probably a continuation of the band on the east shore. From the limestones southerly to Tahsis narrows, on both sides of the narrows, and for two miles south of them, rocks of the Vancouver series are seen, consisting of dark-coloured fine-grained trap.

On the north shore of Hecate channel and the eastern shore of Zeballos arm, as far as the northern end of the arm, the exposures show little variety, consisting of a fine-grained hornblendic rock, weathering occasionally to a reddish brown, which may without question be classed as belonging to the Vancouver series. No granite or limestone was seen on either shore till reaching the point on the west side of the entrance, when grey granite appears, holding at and near its junction with the traps, masses and fragments of the latter.

Esperanza inlet.

From the entrance of Zeballos arm the north shore of Esperanza inlet, to within half a mile of the point of Espinosa arm, is occupied by gray granite. The eastern point of Espinosa arm and the east shore, as far as its northerly head, show nothing but the Vancouver series, and from the head southward on the west shore to within two miles from the entrance, the same rocks are seen. From this point to the entrance of the arm the rock is gray granite with darker masses embedded in it.

Port Eliza.

These gray granites extend round the point of Queens cove and up both shores of Port Eliza to within a mile of its head. Thence to the head, dark green, almost black, hornblendic rocks, holding much epidote, are seen on both sides. On the west side, three miles from the entrance of Port Eliza, a small exposure of hornblendic rock separates the granites.

The shores from Lending hill on the west shore of the mouth of Port Eliza to Point Tatchu on the open coast, six miles to the westward, are formed of the hornblendic rocks of the Vancouver series. These rocks include Catala island and all the small islands and reefs seen in the north channel and Rolling roads, together with Harbour island at the entrance of Port Eliza. On the extremity of Tatchu point, soft bedded sandstones occur, resembling those seen at Point St. Juan, except that no fossil remains were found in them. An ascending section based on the Vancouver series is as follows :—

	Ft.	In.
Fine conglomerate with small beach pebbles......	0	10
Fine-grained gray and reddish sandstone.........	3	6
Coarse conglomerate of beach pebbles, 5" x 4" the largest, some pebbles but little worn; a few beds of fine-grained sandstone less than 4 inches thick..................................	19	6
Fine-grained yellowish-gray sandstone in beds of from 2 feet to 6 inches....................	46	0
	69	10

Nootka sound to Cape Scott.

On the way back to Victoria, a trip was taken by the steamer *Queen City*, from Nootka sound to Cape Scott, but unfortunately the weather both going and returning was so wet and foggy that little was learned of the shores; but much was ascertained as to the best means of carrying on farther explorations. Victoria was reached on October 2.

Glacial striæ are seen in all the arms running inland and generally along the coast from Victoria to Point Tatchu. While the direction

was noted in all cases, further examination inland towards the mountain ranges, from the heads of the arms and fiords, would be necessary to determine the thickness and extent of the ice cap or caps which no doubt covered the greater portion of Vancouver island. The present information gained tends, I think, to show that north of Port St. Juan, all the arms extending inland from the sea held separate glaciers, as in all cases the course of the striæ is with the general trend of the arm in which they were observed.

In the Alberni canal, the evidence is that an extensive glacier reached for a long distance inland and had its discharge through the canal into Barclay sound; while the ice from the north of Kennedy lake found its way to sea-level across the lowlands between it and Wreck bay. Observations through the glass towards the mountains would make it appear that the glacial roundings and markings reach an altitude of at least 2,000 feet. The absence of terraces is probably owing to the steep and rocky character of the shores. Perched boulders were nowhere observed. Glacial evidence in Alberni canal.

The mines on the west coast of Vancouver island seem at present to be suffering from a general depression. The copper mine at Yuka in Quatsino sound is, I believe, the only one shipping ore in any quantity, while there are several properties that might be made productive.

There are several iron claims, in which capital would be, I think, well invested. The copper ores, chiefly chalcopyrite, appear to lie mainly in pockets and are difficult to follow and trace. Nowhere on the coast have I yet seen a true vein carrying ore of permanent value, but it is a country well worthy of being thoroughly prospected. Iron and copper.

Very little land on the west side of the island is available for agricultural settlements. Between Victoria and Sooke, there are numerous farms, but the land is usually very light and gravelly, requiring much manure to produce a crop of grain; but the climate seems to favour the growth of roots and grasses. Around the town of Alberni there is a stretch of good farming land under settlement. Very good land is reported near Cape Scott, where there is a considerable settlement of Danes.

The timber seen in the area covered by this report does not appear to be of much value from a lumberman's point of view. On the exposed part of the coast and along the rocky shores of the arms and bays, owing probably to the lack of soil and to the strong sea winds, which, especially in winter, drive in from the westward and southward, the timber is more or less scrubby and of short grain. One or Timber.

two exceptions were observed, namely, at the mouths of the St. Juan and Gordon rivers and at the head of the Alberni canal. A very few scattered and stunted Douglas firs are seen on the coast itself, but some of fair size were observed at the mouths of streams falling into the different arms, and such trees are reported to be plentiful in the interior. Spruce and hemlock, with some cedars and balsams on the flats, form the chief growth of the forest, while sallal bushes and alders form the chief undergrowth.

GEOLOGY OF THE WEST COAST OF VANCOUVER ISLAND.

Professor Ernest Haycock.

GENERAL OUTLINE OF SEASON'S WORK.

On May 31, I left Ottawa with instructions from Dr. Bell to join Mr. Arthur Webster, at Victoria, B.C., and to engage with him in the study of the geology of the west coast of Vancouver island. I reached Victoria on June 7, and Mr. Webster came over from Vancouver on the 18th. The intervening time was occupied in gathering information from mining men, prospectors, and others, in regard to the region to be examined; in collecting from the government offices, and in studying all the maps and literature available relating to surveys on the west coast, and in examining the crystalline rocks and the superficial deposits of the south and east borders of the Victorian peninsula from Esquimalt to Telegraph cove.

On June 21, our party left Victoria with camping outfit, and after about three weeks spent in the Metchosin and Sooke districts, returned to Victoria on July 11.

Dense covering of vegetation.

Fairly good roads intersect these districts, and outcrops of crystalline rocks are abundant. Away from the highways, particularly near the coast, the country is exceedingly difficult to traverse. The surface is rough and broken, and the minor inequalities are concealed beneath a dense coating of vegetation wherever the smallest accumulation of soil makes rooting possible.

Deep and almost impassable gullies and abrupt faces of solid rock confront the explorer at almost every turn. Huge standing trees and fallen trunks, which often serve as natural bridges over the ravines, form with their interlacing branches additional obstacles, and with a dense undergrowth frequently higher than the line of vision, geological investigation becomes wholly secondary to the problem of progression.

On turning to the sea coast, the difficulties are scarcely less formidable. Vertical bluffs, intersected by deep gullies, face the waters of the straits along much of the coast, and stretches of level shore are so rare that the pedestrian may occupy hours in advancing an insignificant distance.

Character of the sea-coast.

The experiences of the few days spent in attempts to do geological work from the land led to the conviction that examination from the water by boat or canoe was the only method by which satisfactory progress could be made. The Indians too were found to be unreliable, in regard to keeping appointments, if their immediate necessities chanced to have been relieved by the capture of a salmon between the times of agreement and fulfilment. Moreover, as they were reported to be mostly absent from their villages farther up the coast, and engaged either in the Behring Sea sealing or the Fraser River salmon fishing, it was deemed advisable to leave Victoria with an outfit that would allow of regular prosecution of work independent of native assistance.

Examination by open boat.

In pursuance of this plan, on returning to Victoria, a nineteen-foot sealing boat was purchased and provisions for from two to three months were added to the previous outfit. The wisdom of this plan was abundantly demonstrated during the remainder of the season and, with slight exceptions, for the particular work in hand the outfit served every purpose.

Description of the West Coast.

The Pacific coast of Vancouver island, called locally the West Coast forms a broad and regular curve, convex towards the ocean. Its length from Race Island lighthouse, at the southern extremity, to Cape Scott, its north-western, is 250 miles. A straight line joining these extremities lies in a direction 52° west of north, and along its central portion is about 20 miles from the outer coast line. This outer coast line is broken by the entrances of five deep sounds, all more or less choked with islands, and with finger-like extensions radiating among the adjacent hills. Regarding Port San Juan as another of the major inlets, the coast from Race island to Cape Scott is broken at regular intervals of about 35 miles by deep indentations which from south to north are as follows: Port San Juan, Barclay, Clayoquot, Nootka, Kyuquot and Quatsino sounds. The intervening strips of coast, beyond San Juan at the entrance of the strait of Juan de Fuca, are exposed to the full force of the ground swell from 10,000 miles of open ocean, and a heavy surf pounds ceaselessly upon the rocks.

Since it was difficult and even dangerous to make landings for geological examinations upon these exposed stretches of the coast, and also impossible to cover the whole territory during the season, it was

decided to apportion the time among the principal sounds and make use of the coast steamer in crossing the exposed portions. In pursuance of this plan one week was spent at Port San Juan, twelve days on Barclay sound, nineteen days on Clayoquot and one month on Nootka Sound. Excepting the north side of Barclay sound, the entire shores of the above named sounds and their extensions were studied, and, including the portions examined at Victoria and Sooke, a total coast line of 637 miles was gone over during the summer. A large collection of illustrative material was made, including practically every variety of rock met with, and specimens from every important section of the coast. These will furnish material for chemical and microscopical research, which should aid in the elucidation of some of the problems of the field relations of the metamorphic and intrusive series, and the origin of the metalliferous deposits. Kyuquot and Quatsino sounds were not studied, but the latter was examined by Dr. Dawson in 1885, and his description is found in the annual report of the Geological Survey for 1886, page 81 B.

Work done.

At the close of the season, the coast steamer was taken on her monthly trip north, and a passing glimpse was obtained of the remainder of the coast as far as Cape Scott. In returning, our party reached Victoria on September 30.

Physical Features of the Region and their Relation to its Investigation.

That part of Vancouver Island over which geological investigation was prosecuted during the season of 1902 consists of the south-eastern two-thirds of the strip of West coast country, bounded by the Pacific ocean on the south-west and a straight line on the north-east joining Race island and Cape Scott. Its length is 245 miles and average breadth about 12 miles. Its superficial area is approximately 3,000 square miles, and that of the portion studied about 2,000.

Rugged surface.

The surface is extremely rugged and broken. Lofty pinnacled peaks and rounded hills, deep ravines and sharp valleys occupy almost the entire area. Yet, just as the coast line when viewed in a broad way forms an unusually smooth and symmetrical curve, so the elevation of its surface forms a curve even more conspicuously symmetrical than that of the coast line. From Race Island light to Barclay sound the hills gradually increase in elevation from a few hundred to about 3,000 ft.; north-west of Barclay sound the elevation increases, reaching its maximum in the snowy ranges of mountains behind Clayoquot and Nootka sounds. Thence north-westerly, the peaks become less lofty, seldom reaching 3,000 ft. beyond Kyuquot except in the Cape Cook peninsula, and gradually becoming less elevated towards

Cape Scott, where the surface becomes rolling and hilly, and in general resembles that of the south-eastern extremity of the island.

Another leading feature of the West coast is the presence of the large sounds and their extensions previously mentioned as occurring at almost equal intervals from the entrance of the strait of Juan de Fuca north-westwardly to Cape Scott. The wider central portion of the strip of country above outlined is intricately cut up by these arms of the sea, which are without exception deep and perfectly navigable for the largest kind of vessels. Excepting Alberni canal and extension from Barclay sound and Quatsino sound, which lie almost wholly to the north of the imaginary boundary line above indicated, all of these waterways are practically confined to the strip of coast country under consideration. Deep inlet.

The existence of these sheltered inland waters was of the greatest importance to the work of the season. Their shores between tides form practically uninterrupted exposures of the country rock, and landing is almost always easy and safe. The admiralty charts are so accurate that almost any point can be located with sufficient closeness for geological purposes, and by them the stranger can navigate with confidence. Importance of inland waters.

Away from the immediate shore line, the obstacles to geological investigation were of the same character as those met with in the Sooke district but on a larger scale. Standing and fallen timber, dense undergrowth, steep slopes, ravines and boulder beds form the normal surface of the country. Where large streams enter the sea, as at the heads of all the larger extensions of the sounds, considerable deltas or detrital fans of level ground are built out, and these small areas are the only exceptions, away from the outer coast line, to the rule of a precipitous and rocky character for the surface.

From Barclay sound north-westerly along the open coast, a narrow and interrupted coastal plain borders the sea. It rarely or never exceeds two or three miles in width and occasionally appears to exist only in a fringe of low scattered islands or rocky wave-washed ledges, or is wholly worn away by the vigorous marine erosion. Coastal plain.

The presence of this less elevated border along much of the exposed ocean front, the consequent absence of lofty and inaccessible cliffs facing the ocean, and the existence of extensive sandy or gravelly beaches, greatly diminish the difficulties usually met with in land travel in this region, and examination of these yet unexplored portions is regarded as most feasible by foot travel along the coast. Landing places where the forms of the projecting points or outlying ledges break Methods of examination advised.

the force of the ocean rollers, are known to the Indians, and in ordinary summer weather the boat and outfit could be sent ahead to such points while the geologist was making the best of his way to the same points on foot. Such a method would obviate the necessity of returning over ground already examined, a matter of much consequence in a country so difficult to traverse. The same plan of progression is wholly out of the question as soon as the open coast is left, from the abruptness with which the land and water meet, but here the absence of the heavy ground swell permits of the more easy and rapid method of examination from a boat.

Coast south-east of Cape Beale.

South-east of Cape Beale the coast is of a somewhat different character. The coastal bench is higher, and the sea is faced by lines of trap and sandstone cliffs. Sand and gravel beaches are rare, and between Cape Beale and Carmanah point the sea appears to break directly against the cliffs for much of the distance. Between Carmanah point and Port San Juan a shelf of wave-washed sandstone, passable under ordinary conditions of tide and weather, lies at the base of the coast cliffs. From San Juan to Race island, crystalline rocks face the sea abruptly, and travel along the shore is impracticable for other than short distances. As a rule, diminution of the ocean swell as the strait is entered, lessens the surf so that landing is possible on this section at almost any point in favourable weather.

Coast between Kyuquot and Quatsino sounds.

Between Kyuquot and Quatsino sounds, the character of the coast was not clearly determinable from the steamer in passing, except along the outer shore of the Cape Cook peninsula. With this exception the general appearance of the country warrants the expectation of no unusual difficulty in its examination. The appearance of the coast about Cape Cook was, however, repellant. Tidal currents, and perhaps the nature of the bottom, greatly increase the ordinary ocean swell, which pours its volumes furiously upon the rocks and ledges in wreaths of spray and vapour. The coastal bench seemed very narrow or wholly absent, and the retreating sides of the peninsula were rugged, lofty and forbidding.

Hardships.

With the possible exceptions above noted, examination of the whole West coast appears practicable by the methods outlined with a minimum amount of difficulty and danger. With such a frail means of transportation as an open boat, with this one indispensable adjunct so frequently in contact with the rocks in the necessarily innumerable landings, with the occasional necessity of landing in more or less surf, with contents subject to injury or complete loss through accidental wetting, it will be easily seen that with every possible preparation of provisions and outfit against accident, with experienced assistance, and with the best of judgment, accidents are continually possible; and in

a sparsely inhabited country where, during the summer season, a boat or canoe, or an inhabited rancherie may not be met with for days or weeks, even a slight physical accident, or an injury to the boat might assume grave importance and imperil, at the least, the results of a season's work.

On the other hand the weather from June until after the middle of September is fine and agreeable. High winds are exceedingly rare, and rains infrequent. Good water is abundant and mosquitoes and flies are seldom troublesome. Game is plentiful and, on Nootka sound, deer were easily shot from the boat when needed. Salmon and cod may be taken by trolling, and trout are found in the streams. Ducks are abundant in the creek-mouths, and berries are found in profusion at every camping place. Added to all this is magnificent and inspiring scenery, a temperature that does not enervate, an exhilarating air, fresh from half a world of open ocean, some of the most stupendous exhibitions of the results of geological forces, and ever new and interesting scientific problems. Amenities.

Geology.

Excepting the examination by Dr. Dawson of the northern portion of the coast from Cape Scott to Quatsino sound and the briefer studies of the sediments regarded as possibly coal-bearing, which form a more or less interrupted strip along the north-east side of the strait of Juan de Fuca, little or no critical study seems to have been given to the West coast rocks. Previous study limited.

Exclusive of the unconsolidated superficial deposits of Quaternary age, rocks of at least four different periods occur. Two of these series are crystalline, two are consolidated but otherwise almost unaltered sediments.

Metamorphic Series.

The oldest of these rock series occupies, almost exclusively, the whole region over which investigations were prosecuted during the season of 1902. The only exceptions worthy of mention are the small areas of typical intrusive rocks, and a narrow coastal fringe of unaltered sediments along the entrance to the strait of Juan de Fuca. The rocks of this series, wherever examined, were highly metamorphosed. As a rule, the alteration is a complete recrystallization of the original constituents. Schistose structure is often present and when very prominent, as in the San Juan area, appears to be connected with a less extreme alteration. Its obscurity or absence came to be regarded as due to more complete fusion and recrystallization. Distribution. Schists.

Locally the metamorphic series varies widely in composition, texture and structure. In composition these rocks range from non-calcareous, dark coloured, basic rocks, to light coloured, almost pure quartz rocks.

Crystalline limestone.

Massive crystalline limestones are frequently intermingled with them. Occasionally the limestones show gradations upwards or downwards, by means of passage beds becoming increasingly argillaceous or siliceous, to the non-calcareous rocks. More often no transition is visible, the contacts being sharply defined. In the majority of cases the sharp contacts were plainly due to intrusion of an igneous rock. In one case beyond the possibility of doubt the limestone was a sedimentary deposit upon the vesicular surface of a lava flow.

The mineral constituents are as variable as the average chemical composition. Almost pure granular quartz rocks occur, often with intimately disseminated fine grains of pyrites. These range by increasing admixtures of clay to the quartz and mica schists, argillites and slates. Pure calcium carbonate rocks occur, now almost always completely crystalline, forming white marbles, and by the addition of various impurities producing coloured and variegated varieties, dark to black limestones, and a wide series of more or less calcareous rocks. Associated with all these and belonging to the same series is a range of more or less feldspathic and hornblendic, well crystallized rocks, generally dark in colour and basic in composition, but rarely light coloured, with free quartz and acid feldspars predominating. In addition are fine-grained and compact rocks in which the minerals can

Amygdaloids.

not be identified in the hand specimens. These dark coloured basic rocks are frequently amygdaloidal, the amygdules usually filled with quartz and epidote, and the latter mineral is a conspicuous accompaniment of rocks of this character.

The texture ranges from a fine grain without discernible crystal faces to well crystallized masses showing cleavage faces an inch and more in diameter. No glassy rocks were seen, although this character would doubtless be revealed by a microscopic examination of some of

Flow structure and bedding.

the less altered volcanic rocks. Flow structure in felsitic rocks was frequently noticed, particularly about the northern extensions of Nootka sound. Bedding is not infrequently shown, and is the one distinctive characteristic separating the rocks of this series from the intrusives which they often closely resemble. In some portions it shows the alternations and associations of ordinary aqueous stratification. In other portions it is the more or less massive and irregular layering of successive lava flows.

Paucity of bedded rocks.

With the possible exception of the slates, schists and traps, between Port San Juan and Sooke basin, in all the region examined none of the bedded portions was sufficiently unbroken and continuous to jus-

tify an attempt at measurement, or scarcely an approximate estimate of their thickness. The identification of particular horizons in the series has also failed for the same reason, and from the obliteration of the original features that might have served that purpose.

From the geographical extent of these rocks, their moderately high dips wherever the bedding is shown, and the troughs 3,000 to 4,000 feet in depth visibly excavated in their substance, the conviction arises that the thickness of the series must be very great.

Their intricacy.

In mapping the distribution of this series it often becomes a matter of great difficulty to decide whether the rock in question should be classed with the metamorphic, or with the intrusive series. Where stratification is present, even though it is only the massive bedding of volcanic rocks, there is no doubt. But when this is wholly wanting, the problem becomes a difficult one. The importance of this question, and the frequent necessity for passing judgment on critical cases, led to a close search for criteria apart from stratification that would serve when this characteristic was wanting. Towards the end of the season from repeated observations of many typical occurrences of both metamorphic and intrusive rocks, certain criteria were obtained that are believed to furnish tests by which these series can almost always be separated. The accurate delineation of their boundaries may be of considerable economic importance, as the metamorphic rocks frequently contain ore bodies which by some are regarded as original constituents of the sedimentary or volcanic rocks and not to be looked for in the intrusive series.

Relation to ores.

Fossils.

Although fossils were carefully searched for wherever the condition of the rocks warranted the slightest expectation of their occurrence, nothing of any palæontological value was obtained from this series. The limestones of Barclay sound near the entrance of Alberni canal, furnished some poorly preserved organic remains, but no other locality yielded even obscure fossils. Fossiliferous limestone was reported to occur near Sechart in this vicinity, but the locality was not visited.

Dr. Dawson's descriptions.

Dr. Dawson's descriptions of the metamorphic rocks of the northern and eastern portions of the island apply with such exactness to this series of the West coast, that there can be no reasonable doubt of the latter being a continuation of the former. They may thus be considered as belonging to his Vancouver series and mainly of Triasssic but possibly, in their lower portions, of Carboniferous age.

Vancouver series.

The folding and metamorphism of such a vast series of deposits variable in composition, has given rise to rocks that present the widest divergence in point of resistance to denuding agencies. The

result is a deeply incised surface of bewildering irregularity. Up to levels of about 3,000 feet this irregularity has had its sharpness smoothed but its hollows deepened and accentuated by glacial agencies. Above that level the peaks are pinnacled and jagged.

Intrusive Series.

Dykes and sheets.

Rock masses, intrusive in character, are widely and abundantly distributed throughout the territory previously described. Many of these are dykes and sheets, which form in different localities relatively varying but usually small proportions of the whole mass. In composition they vary from dark-coloured basic rocks to light-coloured acid varieties. The basic dykes are most numerous and are believed to be connected with the volcanic masses that form so large a portion of the Vancouver series, and do not call for separate classification in a broad and general outline of the geology. The acid intrusives of this type are in some cases visibly connected with the second group of rocks, to be described. In many other cases they are so near such masses that their origin is not much less certain. For these reasons they may be treated with the intrusive series to which they are so closely related.

Acid intrusives.

Areas of intrusive rocks.

Excepting these occurrences, the areas of unmixed intrusive rocks within the region under discussion are neither large nor numerous. They form both shores of Alberni canal for about six miles northward from the mouth of Nahmint river. A band of varying width is crossed by both of the northward extensions of Kennedy lake, by Tofino inlet and Fortune channel, and occurs in a few small islands near the shore at the northern entrance to Deep pass. From the trend of this band it may be expected to form the north side of Meares and possibly of Vargas islands, but their shores were not examined. The granite area of Alberni canal lies in the line and may be a continuation of the Clayoquot Sound band. If so, it should be crossed by Anderson lake and Effingham inlet, neither of which was visited. Other small areas of similar rocks occur on Shelter arm and Sydney inlet, on Muchalât, Tlupana and Port Eliza arms, and Esperanza inlet, in the Nootka Sound district.

Process of fusion and metamorphism.

Dr. Dawson's description of the contact of these rocks with the Vancouver series on the eastern side of the island agrees perfectly with the contacts frequently observed upon the West coast. The process interrupted by solidification has been one of fusion and incorporation of the metamorphic rocks into the acid magma. The series in which this process was operative is of variable thickness, and frequently

shows all its stages. The angular fragments, in passing out or downwards into the acid rocks, become more separated, lose their angularity, and often pass into irregular sheets, producing a schistose lamination of the blending masses. Considerable areas of these mixed rocks of the contact zone are often met with apart from any visible masses of the intrusive series, and point to the existence of underlying masses of the acid rock, which denudation has not yet revealed.

Granitoid rocks.

The typical intrusive areas are made up of light to dark gray rocks, coarsely crystalline in texture even at their contacts. The essential minerals of granite, excepting muscovite, make up the largest portion of the constituents, but their relative proportions are variable. Hornblende is almost invariably present, and usually in great abundance. The rocks of this series are massive, and much less broken and shattered than the metamorphic rocks. Schistose structure is often traceable, occasionally producing rocks that may be termed gneiss.

Gneiss.

The origin of the rock matter of the intrusive series is almost wholly problematical. The absence of the older rocks upon which the Vancouver series began to be deposited necessitates the conclusion that this substance is, at least, incorporated in the underlying and now intrusive masses.

Copper ores with granites.

Small areas of granite rocks approaching in composition the typical intrusive series above described, occur near Victoria and in the Sooke district. At East Sooke the copper ores appear to be associated with them. When these areas were first studied, the rocks were all regarded as massive igneous, when they were completely and coarsely crystalline, and schistose structure was absent. As a wider knowledge was obtained of the field characteristies and relations of both series of crystalline rocks, more and more of the massive rocks were regarded as altered sedimentary and volcanic masses. Near the end of the season, by the use of the criteria previously alluded to, rocks which in the hand specimen or in field masses showed no trace of stratification or of schistosity, but presented the usual characteristics of plutonic igneous rocks, were unhesitatingly classed with the metamorphic series. The observations of the season thus produced a complete change of opinion in regard to a large portion of the crystalline rocks of the island. Because of these considerations, and the incomplete study of the areas above mentioned, the data obtained are insufficient to warrant a decision on their geological position.

Cretaceous Series.

Unaltered sediments.

The older series of unaltered sediments occur along Quatsino sound and are touched by the head waters of Alberni canal. They were not

Carbonaceous shales.

identified elsewhere within the district examined. The former areas have been described by Dr. Dawson and the latter by Mr. Richardson. Plant remains were found in concretionary masses of the dark brown and black shales at New Alberni, but no effort was made to trace the continuation of these rocks.

Tertiary Series.

Search for coal.

The newer series of consolidated but otherwise unaltered sediments have little in their general appearance to distinguish them from the older Cretaceous sediments, and in consequence have been frequently prospected for the bituminous coal beds that characterize that series. These rocks form a narrow and interrupted marginal band along the strait of Juan de Fuca and a few isolated coastal areas farther to the north-west.

Conglomerate overlaid by sandstone.

The basal beds are generally of conglomerate, largely derived from the rocks of the Vancouver series, upon which they rest without disturbance. These coarse basal beds are of variable thickness, ranging ordinarily between 50 and 100 feet. The upper portions are interspersed with beds of sandstone, which at length wholly replace the conglomerate and add 50 or 100 feet to the total observable thickness. The most continuous area of these rocks, extending north-westerly from Port San Juan to and beyond Carmanah point was not examined, except near the former locality, and the aggregate thickness may be greater in this area. At Coal creek, in the Sooke district, richly fossiliferous layers occur in the upper sandstones. Plant remains frequently accompany the shells, and the whole series consists of beach and shallow water deposits.

Fossil-plants and shells.

In the Coal creek area, and at Sooke, the consolidated and sometimes concretionary sandstones and conglomerates are overlaid by unconsolidated sands and gravels, and by boulder-clay. These later deposits rest unconformably upon the smoothed surface of the sandstone. Just west of Coal creek, trap rocks come through the basal conglomerates, and the upper surfaces of trap boulders of this conglomerate, still in place in the tough matrix, are striated in a direction parallel with the striae on the exposed surface of the trap beds. The glaciation of the surface of the trap rock does not pass under the conglomerate, but disappears at the line of contact, and the underlying surface there shows the characteristic features of marine erosion. From these observations we can conclude that this series of beds had been deposited, and the portions now visible had reached an advanced stage of consolidation before the end of the glacial period. The indications are also

Traps.

Glacial striæ.

that the ice of that period was a prominent factor in the denudation that has removed from the borders of the strait all but a few small areas in the re-entrant angles of the coast line. These observations in the field are, therefore, in general accord with the conclusions reached by Mr. Merriam on palæontological evidence.*

Quaternary Deposits.

Unconsolidated deposits.

Throughout the region covered by the season's explorations, unconsolidated superficial deposits of glacial or recent age are exceptional occurrences. Almost everywhere the underlying crystalline rocks are bare, or but thinly covered by a coating that can scarcely be called soil, yet offers a foothold for a luxuriant growth of vegetation. Within the entrance to the strait of Juan de Fuca, considerable thicknesses of boulder clay, and associated sands and gravels, appear overlying the Tertiary deposits of Coal creek and West Sooke. These lie in somewhat sheltered positions out of the direct line of glacial movement. Generally in this vicinity as well as further to the north-west, the surface is swept clean of deposits, while the contours show heavy glaciation. The materials necessarily removed from the land surface by this process are not now visible, but the charts give some evidence of their occurrence below sea-level.

Glacial action.

Glacial action appears to have been an unusually large factor in the development of the topographic features of the region. The remarkable systems of canals and inlets radiating from the large sounds are old glacier beds, and their great depths are almost certainly due to ice erosion. In contrast with their occurrence and general direction at right angles to the coast north of the entrance to the strait is the remarkably smooth and almost unbroken coast line along the strait, which, like the canals farther north, was a glacial channel but of far greater magnitude. Some evidence from the glaciation of rock surfaces was obtained that points to two periods of glaciation. Traces of the earlier and more extensive ice sheet remain only in the rounded contours beyond the outer limits of the freshly striated surfaces left by the later one. Similar evidence ought to be found on the elevations, which are rounded and smoothed up to and above 3,000 feet, but were not critically examined.

Two periods of glaciation.

Conclusions.

Additional data derived from a study of the charts, when combined with the season's observations, appear to warrant the following conclusions. The submarine coastal shelf has been developed by a process

* NOTE on Two Tertiary Faunæ from the Rocks of the Southern Coast of Vancouver Island. Bull. Dept. of Geology, University of California. Vol. 2, No. 3, pp. 101-108, 1896.

that has been in operation from a time long anterior to the glacial period. Cape Flattery probably marks the southern limit of glacial action upon the Pacific coast line of North America. The earlier and greater ice sheet crossed the present coast line of Vancouver island, and reached out several miles upon the coastal shelf. The limit of the later ice sheet was within the coast line south of Clayoquot sound, but reached that line on Nootka sound. The ice erosion that so conspicuously scoured and furrowed the present land surface operated very lightly on the coastal shelf. It is believed that the period of extreme glaciation was not one of much, if any, elevation above the present level, since those glaciers that did reach out upon, or (as in the case of the great strait glacier) did possibly cross, the coastal shelf, would have excavated deeper furrows in its surface.

Recent marine deposits and old shore lines.

Recent marine deposits assume some importance in the immediate vicinity of Victoria, where they occur about 30 or 40 feet above high tide. At Friendly cove, on Nootka island, the Indian village is built on recent beach-deposits of about the same elevation, and sea-worn caves, now choked with shrubs, occur above the level of the highest tides a few miles farther west. Borings of mollusks were traced up to about the same level, becoming more weathered and obscure towards their upper limit. Similar borings were also noticed in the sandstone at Tatchu point, and indicate a moderate elevation in comparatively modern times. Above this old shore line, with the exception of the Tertiary shelf previously mentioned, no benches were traceable on the slopes of the hills. Small deltas, partly overflowed by the highest tides, occupy the heads of all the deep inlets, and fans of coarse detritus front the entrances of all considerable streams along their sides. They are the most recent of the deposits and their construction it still in progress.

Economic Considerations.

Timber scarce.

The natural resources of the West coast of Vancouver island are almost wholly undeveloped. The timber visible from the coast is scarcely sufficient to warrant any expectation of its ever forming the basis of a large industry. Small areas of good timber usually occur on the deltas at the stream mouths, and in some cases appear to continue for some distance up the valley bottoms. The area that seemed to offer the best outlook was that of the San Juan valley, which is two or three miles in width and runs back several miles. A lumber camp was established in this vicinity late in the summer, and operations were reported to have begun upon a considerably larger scale than heretofore. About Barclay, Clayoquot, and Nootka sounds the surface of the

country is so broken, and the stream valleys so narrow that large and accessible timber areas are not to be expected. South of Kennedy lake a considerable area of more level land may prove one exception to the general rule.

The fishing industry of the West coast gives far greater promise than the lumbering. Only one salmon cannery, at the entrance to Kennedy lake, is at present in operation on this whole coast. A second was in operation for a time on Muchalât arm but was abandoned because of lack of fish. Under the present laws relating to methods of fishing, this branch of the industry gives little prospect of development. Salmon occur, however, in all the coast waters in considerable abundance, and the great numbers that annually resort to the Fraser and other adjacent mainland streams are believed to come up the strait of Juan de Fuca along the Vancouver Island coast. Consequently the recent proposal to permit the use of set traps, in addition to the present drift net methods for their capture, resulted in a wild rush to secure locations and every favourable and accessible stretch of shore between San Juan and Race island was staked for this purpose at the earliest lawful date. The future prospects for this method of fishing in all the large inlets farther north is regarded as very promising. Should trap fishing become lawful on the Canadian, as it already is on the United States side of the boundary line, salmon canning on the West coast may become a large and profitable industry.

Salmon fisheries.

Use of set traps.

Very little attention is at present given to the deep sea fisheries of British Columbia. With the increase of population in the central and western portions of the continent, and development of transportation facilities, the demand for this cheap and wholesome food product must become large, and bring about the establishment of fishing villages in the numerous good harbours of the coast.

Deep sea fisheries.

Any immediate or early advance in wealth and industry on the West coast is dependent on its mineral resources. Although the country is still largely unexplored, what is known of the rocks and their associated ores, gives rise to a firm belief in their great value and future possibilities. With respect to their mineral contents, the west coast rocks may be considered in three groups—the crystalline rocks, the consolidated sediments, and the superficial deposits.

Mineral resources.

As has been previously stated, the crystalline rocks occupy nearly the whole of the land surface of the West coast country. The great thickness of these rocks, their diversity of composition and origin, the extreme geological forces to which they have been subjected, their

Ores of the crystalline rocks.

broken and faulted condition, and the extent to which they have been cut by intrusive dykes, sheets, and plutonic masses, are all features regarded as favourable for the occurrence in them of valuable and extensive ore deposits. The navigable inland waters are also highly favourable to the cheap transportation of both supplies and products.

Actual occurrences of ores in these rocks have already been reported from localities too numerous to mention, and a few of these, upon which some work has been done or was in progress, were visited. Brief examinations, and series of specimens illustrating the ore, gangue, and associated rocks, were made at East Sooke, Newton's camp on the Gordon river at San Juan, the Happy John group of claims near the entrance of Alberni canal, and Copper island on Barclay sound.

Iron and copper ores.

The usual sulphides of iron and of copper and iron, in a hornblende gangue, occur at the Blue Bird claim at East Sooke, the whole immediately associated with masssive crystalline rocks, occasionally of very coarse texture. Three or four miles farther south near the outer shore of the East Sooke peninsula, deposits of magnetite occur, with varying amounts of the above named sulphides, associated with what were regarded as the metamorphic rocks. Disseminated particles of pyrite and chalcopyrite are here widely distributed. They occur as constituents of the country rock, as well as in veins and joints. Specks of native copper were also occasionally observable on the joint surfaces.

Native copper.

At Newton's camp on the Gordon river the work was stated to be wholly of the nature of development. Although the ore body was not cut by the shaft that was then being put down, and had reached about 300 feet, magnetite was a common constituent of the crystalline rocks on the dump. The surface outcrop of the ore body was not seen. The rocks along the trail and visible at intervals are of the metamorphic series, and considerable masses of limestone occur in the vicinity.

Alberni canal.

Several groups of claims are located on the north side of Alberni canal near its entrance. Considerable development work was reported to have been done on the Monitor and Hayes groups and some ore shipped. No work was in progress at the time of our visit and only one of the occurrences cf the vicinity was examined. The ore at this claim—the Happy John—was a chalcopyrite associated with limestones which were closely intermixed with dioritic rocks. On Copper island, a few miles to the south-west, the ore is a magnetite associated with dioritic rocks. Limestones occur in the vicinity and the ore-bearing rocks appear to belong to the metamorphic series. Other deposits of

magnetic iron in this vicinity are reported from the Sarita River valley and from Sechart.

A closer and more continued study of these and other occurrences is much to be desired, as, until more accurate and complete knowledge is possessed of some typical occurrences and their field relations, the possibilities and probabilities of discoveries in rocks of other localities are largely matters of chance. Copper island is regarded as one favourable locality for such study of the magnetic iron ores. The coast of the island offers an exposure completely surrounding the area, and a large portion of the surface near the deposit is bare of vegetation. Further examination desirable.

Similar rocks and associated ores occur on Clayoquot and Nootka sounds, and the highest expectations are held that some of the known, and other yet unknown occurrences, will prove extensive and valuable. Nootka sound.

The consolidated sediments of the West coast can scarcely furnish any contribution to the mineral resources of the country. It is possibly otherwise with the area of these rocks about the head of Alberni canal. If this area should be found to contain workable coal beds of considerable extent, the conditions would probably be highly favourable for the establishment of a great industry at that point. With abundant iron ores on Barclay sound and limestone in unlimited quantity immediately upon the water front at the entrance of the canal, and the canal itself forming an ideal highway for water transportation, such a discovery would apparently make up a rare combination of advantages for the economical production of iron. Should the quality and quantity of the Barclay Sound iron ores fulfil the sanguine expectations of the present owners, it does not seem at all unlikely that Alberni may become the seat of such an industry, as coal occurs not far distant in the Nanaimo and Comox fields, and the intervening country offers no great engineering difficulties to railroad transportation. Ores of the consolidated sediments. Coal.

Pleistocene and recent deposits are of such limited extent upon the West coast that they cannot add much to the mineral wealth of the country. The beach sands of Wreck bay, between Barclay and Clayoquot sounds, have yielded some gold, and this is said to have been derived from the superficial deposits immediately to the rear of the beach. With limited exceptions, however, the ice of the glacial period swept off beyond the present shore-line the loose surface materials that had been accumulated previously to its advent, and with them a considerable thickness of the rock upon which they rested, thus eliminating almost all possibility of the occurrence of placer deposits of any extent along the coast. Ores of recent deposits. No gold.

Conclusion.

The field observations of the present summer have probably brought under notice every geological formation of any importance that occurs on the coast, and in part have established their relations. On the other hand, the examinations of the separated areas were not connected, the difficulty in penetrating the country and want of time forbade the tracing of outcrops or contacts of any formations away from the shore, and the rocks being mainly crystalline, closer study by chemical and microscopical methods should supplement the field examination. Because of these considerations the conclusions reached need not be regarded as final. Still, it is thought best to state them, along with the recorded observations, as more or less probable working hypotheses suggesting and stimulating further investigations.

Preliminary Report on the Boundary Creek District, British Columbia.

Mr. R. W. Brock.

Introduction.

On May 29, I left Ottawa with instructions to first make a detailed survey of the Boundary Creek district, and then to make a reconnaissance survey of the West fork of the Kettle river. I was accompanied by Mr. W. H. Boyd, of this office, who took charge of the topographical branch of the work. Greenwood, as the central town of the district, was selected as headquarters for the season. The area embraced in the Boundary Creek map-sheet is that lying north of the International boundary line and south of Pass and Lost creeks, between the North fork of the Kettle river, and a line from a little west of Midway north between Copper and West Copper camps. Within this area lie all the mining camps of the Boundary Creek district at present being worked or opened up. The work was done in sufficient detail to enable an accurate map, on a scale of one mile to the inch to be constructed. The uniform elevation of the mountains, the frequent forest growth on their summits and the irregularities in the topography made it necessary to fix a very great many transit stations. The intricate mixture of many different rocks of different ages made the geological work difficult and slow, so that more time was consumed in the survey of the sheet than had been anticipated. The season was hot and dry. In the latter part of August the daily range of temperature was very great, extremely hot days succeeding frosty nights. Just before completing the map-sheet, toward the latter

Area covered by map-sheet.

part of August, the sun proved too much for me and I was ordered home by the doctor. This made the intended reconnaissance survey of the West fork of the Kettle river impossible. I remained in camp, however, to look after the completion of the geological work on the Boundary Creek sheet, returning to Ottawa on Sept. 22. Mr. Boyd remained in the field two weeks longer to complete the topographical data.

The Topographical Map.

The method employed by Mr. Boyd in the topographical work was triangulation by means of numerous transit stations, with careful sketches drawn to vertical and horizontal scale, commencing from a base surveyed along the railway spur on the midway prairie. This triangulation was tied on to the International boundary monuments, to mineral monuments and to stations used in the West Kootenay sheet east of the North fork of the Kettle river.

The triangulation was supplemented by numerous road and trail odometer and paced surveys between fixed points, using prismatic compass and aneroid barometer. Similar traverses were made of numerous ridges and valleys. With the exception of some of the traverses, all the topographical work was done by Mr. Boyd. He also rendered material assistance in the completion of the geological work after my illness.

A reconnaissance survey of part of the district was made last year, and its general characters are described in the Summary Report for the year.*

Physiographical Features.

The area covered by the Boundary Creek sheet possesses the characters of an older mountain district. The mountains have been worn down below the limit of intense Alpine erosion and appear as rounded ridges or dome-shaped summits of a nearly uniform elevation of about 5,000 feet. The uniformity in elevation of the mountains cannot here be taken as indicating that the country is a dissected peneplain.

It is due to the wearing down of Alpine peaks by erosion. Above the tree line when frosty nights succeed hot summer days and the rocks are unprotected by soil or vegetation, the erosion is intense and the mountains wear down rapidly. As soon as a ridge or mountain is cut down to the base of this zone of rapid erosion, its degradation

Plain of erosion.

* Summary Report of the Geol. Survey for the year 1901, pages 49-67.

Erosion of mountains.

becomes very much slower, while the peaks still standing in this zone continue to be heavily attacked so that they are in turn cut down to the base before the former have retreated much below it. Consequently about the tree line and for some distance below it, the mountains and ridges may possess a rather uniform elevation, as is the case in the present map-sheet. But while the regularity in form or elevation is mainly due to erosion, it is in part owing to the filling up of old irregularities in the surface by the Tertiary lavas which once covered the entire surface of the sheet and which may still be found capping many of the ridges or frozen to their flanks. Glacial erosion may also have been effective in reducing inequalities in the surface relief. The valleys form a well marked longitudinal and transverse system. The North fork of the Kettle river and Boundary creek are longitudinal valleys. The transverse valleys are off-sets from these. The valley of the main Kettle river which merely touches the S. W. and S. E. corners of the sheet, forms in this part of its course an important exception, running across the general trend of the mountain ranges and primary valleys.

Modification through glaciation.

The west arm of Kootenay lake and the river from it to the Columbia in the West Kootenay map-sheet furnish an illustration of a similar irregularity. While in general the structure, form and elevation of the mountains are regular; in detail they are more or less complex and irregular. Owing to differences in the resistance of different rocks to the agents of erosion, the ridges are often notched or rise into elevations, breaking the regularity of the distribution of summits. There have been important changes in the drainage, brought about by one stream eroding backward and capturing waters of another, and in other ways. Probably the chief factors in these changes have been the Cordilleran glacier which scoured this country and local remnants of it, though it is often difficult to say just what has resulted from ordinary river erosion, what from glacial erosion and what from differential uplifts. The most obvious effects of glacial erosion have been the straightening of valleys, with a tendency to produce longitudinal valleys (these have the general course of the glacier), the alteration of the V-shaped valley to the wide U-shaped valley, and the truncation of the ends of ridges between adjoining transverse valleys. The glacier also deepened the main valleys. The deepening of these main valleys, coupled with the truncation of the ends of spurs separating lateral valleys has produced many hanging valleys. That is the beds of many of the transverse valleys are high above the floor of the trunk valleys, so that the streams occupying them debouch in waterfalls or have been forced to cut canyons down to the level of the trunk

Hanging valleys.

stream. The little tributaries of the North fork of the Kettle from the west almost all occupy lofty hanging valleys.

The bottom of Boundary Creek valley is considerably above that of the main Kettle river, so the creek is cutting a canyon back from its mouth. Boundary Falls is at the head of this canyon.

The character of these valleys while not so marked as in the main valleys of West Kootenay, is still distinctly fiord-like, and this character is to be attributed to glaciation. In the case of many of the creeks a narrow canyon-like trough has been cut in the widened valley bottom since the ice vacated it. Brown creek, in whose valley a great deal of glacial material has been deposited, has cut its trough, not in the deepest part of the rock bottom, but along the north side of the valley.

The creeks occupying hanging valleys have generally built up alluvial fans where they discharge into the deeper valleys. A good example of such a cone of dejection is seen in Eholt Creek valley where the torrent from Long lake enters. As examples of changes in the drainage due to the combined efforts of ice and river erosion, Long lake and the North fork of the Kettle may be mentioned. The North fork, even in post-glacial times, flowed west of Observation hill, as pointed out in the Summary Report for 1900. A small lake occupies a portion of its old channel and the depression of its bed on the Grand Prairie flat west of the town of Columbia can be distinctly traced. At present it flows east of Observation hill. The glacier probably cut down the neck of rock joining Observation hill to the mountains to the east in a sufficient degree to permit river erosion to do the rest. Long lake formerly discharged into Pass creek. A saddle-shaped ridge probably divided Pass Creek waters from the Eholt slope. This the glacier cut down to a wide, almost level col. A deposit of gravel probably morainic on the Pass Creek slope caused Long lake to form. At first it discharged down Pass creek, but a small tributary of Eholt creek by headward erosion tapped it and reduced its level slightly so that now it forms a part of the drainage system of Eholt creek. The lake is deepest near its Pass creek end (a little over 64 feet), is separated from Pass creek by the gravel deposit which is about twenty feet higher than the lake level and sloped towards Pass creek. Marshes occur on it which still drain into Pass creek. Numerous examples might be cited of drainage alteration but these will be discussed in the general report.

Changes in drainage.

The gradient of the main valleys is low, except where they empty into a more deeply trenched valley. The transverse valleys are

usually steep at the head, of low gradient along the middle reaches, and very steep again as they near the trunk valley.

Glaciation.

Other evidences of glaciation besides the form of the valleys are to be seen everywhere. Erratic boulders are perched on the sides and summits of the mountains. Often, for example, granite boulders of great dimensions are to be found lying on volcanic rocks. In many cases the ice has carried them across wide and deep valleys. Some must have been transported a great distance but the majority can be traced to their origin, not many miles from their present position. They have as a rule travelled a little east of south. Polishing and scoring by the glacier are to be seen in many places, sometimes even on the ore bodies. The direction of the ice movement as shown by the striation on polished surfaces of the rocks, is influenced by the local topography, the ice having a tendency to move in the direction of the principal valleys. On the summits of ridges and mountains, it shows greater independence. It varies from S. 15° W. to S. 41° E. An average of a great number of readings gives S. 18 E. as the general direction of flowage. (These readings are astronomic—the magnetic variation is 24 E.) The ice sheet which covered this part of the country was no doubt part of the Cordilleran glacier which was shown by Dr. Dawson to have travelled in a direction of S. 30° E. in the Kamloops district,* and which has been proved to have had a similar course over the Kootenay district.†

Boulder clay was not observed in the Boundary Creek district but resorted glacial material is widespread. It is frequently found as terraces of gravel, sand, silt and beds of clay skirting the hill sides along the main valleys. In favourable locations the terraces may extend to a height of at least 2,000 feet above the valleys. Good examples of these terraces may be seen on Boundary creek and the Kettle valleys.

On the hill west of Boundary creek near its mouth, terraces extend almost to the summit of the hill; at least fourteen are plainly visible.

Drift and wash cover a large part of the district, the rocks to a large extent protruding as knees and elbows.

Ranch lands

The terrace flats on Boundary and the Kettle valleys afford good ranch lands, though irrigation is sometimes necessary. For this purpose the numerous streams are valuable. The open hill-sides, which are not infrequent, afford good grazing ranges.

---

* Annual Report Geol. Surv. Can. 1894, Part B. † Summary Reports, 1898-9-1900.

The northern slopes of the mountains and the narrow valleys, are generally well wooded, except where they have suffered from forest fires. Southern slopes are often open and grassy.

Forest.

Eastern and western slopes may be forested, park-like or open. The main Kettle valley is for the most part open prairie. The south-west corner of the district is more open than the remainder. The northern part, where the mountains are rising to more rugged peaks, is for the most part tree-covered.

The tendency is for narrower valleys, or summits to be wooded and the hill-sides to be open, owing to the greater precipitation on the summits, and the irrigation by streams in the valleys.

Timber for mining is usually to be had in the vicinity of the mines. Larch, hemlock, fir, spruce and pine are the most abundant trees. The open hill-sides support a luxuriant growth of bunch grass. Near Midway the climate is somewhat drier and sage brush, prickly pears, and sand roses make their appearance. The vegetation as a whole is similar to that of West Kootenay outlined in the Summary Report for 1900.

FUNDAMENTAL GEOLOGY.

While, for a mountainous district, travelling is easy, prospecting and geological work are made difficult by the extreme variety and complexity of the rock formations and the widespread covering of wash. Sedimentary, pyroclastic, igneous, both plutonic and volcanic, and metamorphic rocks all occur, of from possibly pre-Palæozoic to Middle Tertiary age.

The geological formations met in the district, and their approximate or relative ages in descending order, are as follows :

GLACIAL AND RECENT DEPOSITS.

Formations represented.

Quarternary Tertiary.	Volcanic flows, andesites, basalts, &c. Injections of intrusive sheets, dykes and plutonic masses. Ore deposits, volcanic flows. Tuffs, ash beds, volcanic conglomerates, sandstone and shales with a little lignite.
Jurassic ?	Granodiorite.
Post-Palæozoic ?	Serpentine. Green porphyrite.
Palæozoic ?	Green porphyrite. Volcanic conglomerates, tuffs, ash beds with arenaceous limestone. Serpentine. Limestones, argillites, quartzite.
Crystalline schists ?	Gneisses and schists.

Except the Tertiary tuffs, sandstones and shales, which yield a few obscure forms, none of the rocks are fossiliferous, so that the geological ages as here given are subject to revision. They have been determined by stratigraphical relationships and the striking resemblances of the lithological units to those found in the Rossland and Kamloops districts, where their geological horizons have been fixed by palæontological evidence.

The crystalline schists.

The oldest rocks of the district are the crystalline schists and the sedimentary rocks. In the south-east corner, a limited amount of crystalline mica and hornblende schists with interbedded crystalline limestones are exposed. These rocks have a strong lithological resemblance to the Archæan rocks of the Shuswap series, and are the oldest rocks found in the area covered by the present map-sheet, but they may possibly be more highly metamorphosed argillites and limestones such as are found elsewhere in this district.

Limestone and argillite.

The limestones, argillites and quartzite, cut by serpentines, form a series which closely resemble the Cache Creek series (Carboniferous) of the Kamloops district. They occur in areas of greater or less extent in almost all parts of the district. They are always more or less metamorphosed; the limestone is generally white and crystalline, although occasionally a core of black or drab limestone is to be seen; the argillites are or were somewhat carbonaceous but are frequently altered. A hornblende or mica schist found in the Long Lake region seems to be an alteration form. Frequently both the limestone and argillites are altered by silicification which, when complete, produces a quartzite-like rock. In the argillites, quartz films and bands are often found parallel to the foliatiou. Some apparently true quartzites occur. The rocks also show the effects of mechanical deformation. The limestone is in places brecciated. These sedimentary rocks are among the oldest in the district. They are cut and greatly disturbed by the later intrusions of eruptive rocks so that little can now be determined regarding their thickness and original stratigraphical relationships. They seldom form large continuous bands but generally appear as islands of greater or less extent in the intrusive rocks. They probably form parts of a once extensive series of sediments which covered southern British Columbia.

Serpentine.

The serpentine occurs as bands and masses cutting these sedimentary rocks. The intrusive nature of the serpentine is shown in the way in which it cuts across the bedding of the older rocks and in the contact metamorphism it produced. In places traces of the structure of the

original eruptive rock can be made out in the serpentine. In Central camp the serpentine is occasionally somewhat fibrous, approaching asbestos. Near the Koomoos-McCarren Creek divide it seems to pass into a soapstone or talc. Often it is altered to a rusty aggregate of dolomite (and perhaps other carbonates) and white quartz veins. It is doubtful if all the serpentine in the district is of one age. Boulders of serpentine are found in the green volcanic conglomerates which would indicate that some of it was older than these pyroclastic rocks. On the other hand, some of it seems to be intrusive in the green porphyrite which is of a little later age than these volcanic conglomerates. The serpentines are found in Smith's, Wellington and Summit camps and the country to the south. They are particularly abundant in Attwood and Central camps.

The older pyroclastic rocks and porphyrites are widespread; in fact they are the commonest rocks in the district.

Porphyrites and volcanic conglomerates.

This series of rocks consists of green tuffs and volcanic conglomerates and breccias, fine ash and mud beds, flows of green porphyrite, and probably some interbedded limestones and argillites. The tuffs, conglomerates and breccias consist of a mixture of pebbles and boulders of porphyrite material with a great many fragments (probably a large proportion) of the rocks through which the volcanics burst. Pebbles and boulders of limestone, argillites, jasper and chert are common. Those of serpentine and old granite and old conglomerates are much rarer. In form, the pebbles and boulders are rounded, subangular, angular and of irregular and fantastic outline. Sometimes they are somewhat sorted but often they are tumultuously arranged (agglomeratic). Beds of mud, ash and tuff alternate rapidly with coarse volcanic conglomerates and agglomerates. Sometimes the matrix seems to be formed of porphyrite injected between the boulders. Limestone, now crystalline, seems occasionally to have been interbanded with them. It is often arenaceous, bands containing rounded sand grains and pebbles alternating with pure limestone. The sand and pebbles are well sorted and these arenaceous bands are sharply defined from the pure limestone. The matrix of these bands is white crystalline limestone. Argillites are also interbanded to a limited extent, although it is not always possible to distinguish the volcanic muds from such sedimentary material.

The porphyrite seems to be a little later than most of the pyroclastic rocks although some of it may be interbanded. Owing to the alteration in these rocks through mountain building processes and contact metamorphism, it is not possible to separate the porphyrites

from the pyroclastic rocks, on the map. The porphyrite is usually too highly altered to make out its original character, but it seems to have been an augite-porphyrite similar to that of the West Kootenay district. In places it is agglomeratic.

Origin of rocks difficult to trace.

The great changes produced by mountain building processes and later igneous intrusions, make it difficult or impossible to discover the history of these rocks. The first part of this period of volcanism seemed to have been one of heavy explosions with periods of sedimentation, and to have been followed by a period of more quiet lava flows. The amount of material extruded must have been very great.

A very striking feature in these rocks is the way in which islands or irregular masses of the older sedimentary rocks appear in them. In part, these are included fragments, in part they may represent infolded masses in truncated anticlines, or inequalities in the surface on which this old volcanic series was deposited. Appressed anticlines and faults can be seen in them, but the grand features of their structural relationship are lost through the effects of the later igneous intrusions. Some of the limestone inclusions are to be explained as squeezed intercalated beds. Under pressure, the limestone may flow and from a thin bed, a line of inclusion-like lenses may be formed. This series of pyroclastic and volcanic rocks seem to have been formed immediately after the sedimentary series, and is therefore probably Palæozoic. In the Palæozoic formations of the Kamloops district, also, green effusive rocks occur.

As already remarked some of the serpentine appears to be of later age than this series.

On the west end of Baker mountain and at the head of Fisherman creek a tough green porphyrite occurs which seems to overlie the sedimentary rocks and old green volcanic and pyroclastic rocks. It looks fresher than the old green porphyrite, and may represent a later eruption. It is an agglomerate in places.

Granodiorite.

At various points throughout the whole district bosses, irregular masses, and dykes of a light gray granitoid rock make their appearance. It is a quartz-bearing biotite-hornblende rock, in places apparently granitic, in others rather dioritic. It is probable that it will prove to be, generally, a granodiorite. It sends out numerous dykes throughout the country, especially in the southern portion of the district. These have usually a porphyritic structure with a microgranitic groundmass. Some are granite porphyries, but a great number are quartz-diorite-porphyrites, as are also some of the smaller

bosses. On McCarren creek, north side, are some basic hornblende gabbro-porphyritic dykes which may belong to the same intrusion. In places these shade off into pure hornblende rocks.

This granodiorite is evidently intrusive, cutting all the rocks above mentioned. The mechanism of its intrusion is extremely interesting, for it unquestionably forced its way up through the overlying rocks by digesting them and rifting off fragments. This is proved by its contacts, both along the sides and roofs of the masses. These are, except in the case of the dykes, rarely sharply defined, but are irregular and suture-like. The intrusive holds inclusions of the surrounding rocks, and the surrounding rocks are often filled with granite material. The composition of the intrusion seems to be affected by the digested material of the rock into which it has forced itself. It is also shown by the way in which the granodiorite is exposed in small, more or less circular but irregularly bounded masses, in different parts of the district, such as in Wellington camp and on Hardy mountain. In many cases no definite boundary can be assigned to the granitic mass. From the way in which the rock makes its appearance in all parts of the district, it is evident that the whole of it, at no great depth, is underlain by this rock. This rock has some strong resemblance to the Nelson granite of the Kootenay district, both in composition and in its relationship to the surrounding rocks. The Nelson granite, which has been carefully studied, is a sort of granite representative of the Monzonite group of rocks, intermediate between the alkali and the lime-soda series of rocks, and about on the boundary line between granite and diorite. Its composition is as follows:— Mechanism of its intrusion. Nelson granite.

SiO_2 66·46	TiO_2 0·27	Al_2O_3 15·34	Fe_2O_3 1·68
FeO 1·83	CaO 3·43	MgO 1·11	Na_2O 4·86
K_2O 4·58	H_2O 0·29	P_2O_5 0·08.—Total 99·93%.	

—*Analysis by Dr. F. Dittrich, Heidelberg.*

The Boundary Creek rock will probably be found on analysis to contain a greater percentage of alkaline earths, but this may be due to the material it has acquired from the rocks into which it has been intruded, and may represent only a local peculiarity. As the Nelson granite occurs to the north and east of this district and probably also to the west, the Boundary creek rock in all probability belongs to the same great intrusion. If so, its age will be about Jurassic. This agrees with its stratigraphical position in this district.

The remaining rocks of the district are of Tertiary age, with the possible exception of a few dykes whose age is uncertain. These rocks, Tertiary rocks.

which occur in great abundance in the district, are for the most part of igneous origin. They prove that this part of the country, as well as other portions of southern British Columbia, where they also occur, was the scene of tremendous volcanic activity during Tertiary times, comparable in magnitude with that of Idaho, Washington, Oregon, etc.

Stratified rocks.

The oldest Tertiary rock is a coarse conglomerate which occurs on Baker and Thimble mountains. It is a coarse conglomerate containing boulders of all the older rocks of the district with some of volcanic origin. It resembles the basal conglomerate underlying the volcanic rocks of the West Kootenay district* and may perhaps correspond to the Coldwater group of Oligocene age of the Kamloops district. It is probably of fresh water origin, and may represent an old river bed. Overlying this conglomerate, but in many places resting directly on the older rocks, is a white gritty tuff, consisting largely of fragments of quartz and feldspar, with a little calcareous and ash matrix. This rock is locally known as 'sandstone,' and also as 'porphyry.' It is much more widespread than the conglomerate. In Copper camp, near Ingram creek, some sandstones and shales occur holding fossil plants altered to lignite. In Copper camp these are scattered through the rock, but on Ingram mountain a bed several feet thick of lignite occurs. Here some sheets of lava are interbedded with the sandstone, but generally the lavas are younger and overlie the pyroclastic or sedimentary rocks, where these occur, or rest directly as a capping on the pre-Tertiary rocks of the district.

Lignite coal.

Lavas.

The volcanic flows are present in great thickness. In composition they vary from a dark heavy olivine-bearing basalt to light coloured andesites, dacites, trachytes and possibly rhyolites.

The earlier eruptions were evidently from local vents and explosive in their nature, as shown by the beds of tuffs and their irregular distribution, and the occurrence of volcanic plugs at Phœnix, near Summit City and on Thimble mountain. These are, however, not the earliest vents as they pierce the gray tuffs and the lower volcanic sheets.

The later volcanic flows, from their wide distribution and absence of tuffs, have probably come from fissure eruptions.

The basic lavas are often amygdaloidal or scoriaceous. The vesicles are frequently filled with chert, agate or zeolites.

*Summary Report for 1900, pp. 67, 70, 74.

The basalts are commonly coated with a green material which prospectors have mistaken for copper carbonate. It appears to be largely composed of manganese, copper being entirely absent.

These volcanic rocks are similar to those described in the West Kootenay district* and in the Kamloops district.† Dr. Dawson subdivided the Kamloops volcanics into a lower and upper group, both of Miocene age. This subdivision cannot be made in the Boundary Creek district, nor was it feasible in the Shuswap district.

Capping dissected by streams.

These rocks, which once formed a continuous capping over the whole of the district, except perhaps the highest peaks, have been dissected by the streams and now occur for the most part as isolated outliers on the tops and sides of ridges. This is their mode of occurrence at the northern and eastern parts of the sheet. They form an almost continuous capping among the range west of Boundary creek to the International boundary line, though cut through by Wallace creek, partly cut away by Copper creek, and in some places by the Kettle river.

Some of the little remnants of these volcanic rocks are too small to map.

Their occurrences in Copper Creek valley, in Jolly Jack creek valley and Kettle river valley, far below exposures of older rocks, show that these were valleys in early Tertiary times.

Movements after extrusion.

The attitude of these rocks, however, prove that mountain-building forces were at work after their extrusion. In places the tilting of the beds might be explained by deposition or solidification on an inclined surface, in others as near as Eholt on the Columbia and Western railway, where they form a syncline trough, it might be explained by the intrusion of the alkali-syenite rocks described below. But on Copper creek where the volcanics and underlying sandstones are tilted sixty degrees or more to the east, neither of these explanations will apply. So that it is certain that considerable movements of the earth's crust occurred here in Middle Miocene times, if not later. The ore-bodies, which as will be shown later, were formed about the same time, would be subjected to the same movements.

Besides the volcanic plugs, such as those at Phœnix (which cut the tuffs and lower volcanic sheets, and whose material is identical with that of some of the basic flows) bosses, dykes, intrusive sheets and possibly surface flows of alkali-syenite material occur, which are newer than at least the lower members of the Tertiary volcanic group.

---

*Summary Report, 1900. †Annual Report, G. S. C., 1894, Part B.

Alkali syenites and alkali syenite porphyrics.

Where occurring in a boss or large dyke the rock is medium to coarse grained, pink to grayish, consisting largely of feldspar of somewhat glassy habit, some biotite and a little diopside and hornblende, with accessory apatite, magnetite and titanite. A little nephaline and sodalite also occur in it. The feldspars are microperthite and albite, with perhaps anorthoclase. They are sometimes idiomorphic with a tendency to arrange themselves in parallel alignment or radially around a bisilcate. The bisilicates form but a small percentage of the rock, and of these, biotite is the most important. The hornblende is a bluish green variety with high extinction and strong dispersion. In the powdered rock a blue mineral with the characters of riebeckite was detected, so that this hornblende is probably an accessory mineral.

This rock is an alkali syenite, probably of the Pulaskite type. In the smaller dykes it has the structure of a porphyry and is therefore in such cases, an alkali syenite porphyry. The groundmass is often very finely granular and the phenocrysts are rosette-like aggregates of feldspar crystals with an occasional one of biotite.

There are also dark lamprophyric dykes and light bostonite-like dykes which are probably connected with this rock.

Analysis of pulaskite.

This alkali syenite or pulaskite is the same rock as the Rossland syenite that is widespread over the western part of the West Kootenay district.* An analysis of the latter gave the following results :—

SiO_2	62·59
TiO_2	0·54
Al_2O_3	17·23
Fe_2O_3	1·51
FeO	2·02
MnO	Trace
MgO	1·30
CaO	1·99
K_2O	6·74
Na_2O	5·50
P_2O_5	0·11
H_2O direct	·30
CO_2	Trace
Cl	Trace
SO_3	Trace
	99·83—*Analysis by Dr. F. Dittrich, Heidelberg.*

* Summary reports, 1898–1900.

This analysis agrees closely with those of previously described pulaskites.

The alkali syenite bosses and dykes are particularly numerous in the northern half of the Boundary Creek district. North of the sheet is a large area of it. They are newer than and intrusive into all the rocks of the district with the possible exception of the latest volcanics. The most common mode of occurrence in the map-sheet is as porphyry dykes or intrusive sheets, but some horizontal sheets exposed on the surface may have been surface flows, and some of the lavas seem to have about the same composition. From their relationship to the volcanic rocks, it is probable that the latter are alkaline in composition and that the alkali syenites plug the vents through which the later flows reached the surface. Alkali syenite

Besides the rocks above described some dark basic dykes occur which seem to be connected with the volcanics.

The distribution of the various rocks will be shown on the map and need not be described here. Distribution of rocks.

The commonest strike for the sedimentary rocks as well as for the various dykes is about N. and S., but many exceptions occur, as is natural in an eruptive area.

The Ore Deposits.

The ore bodies may be divided into three groups. (1) The large low grade copper-bearing deposits, (2) Oxydized coppèr veins, (3) Gold-bearing and silver-bearing veins.

Low Grade Copper-bearing Deposits.

According to the form of the deposit this group might be subdivided into—

(*a*). Huge bodies, of as yet unknown form, and dimensions, as the Mother Lode, Knobhill-Ironsides. In the Mother Lode the ore, as tested, outcrops for 2,000 feet. The average width is about 140 feet, (though the walls are not natural but rather commercial) and the ore is continuous to the bottom workings, at present 500 feet below the highest point of the vein. The Knobhill-Ironsides lead, extends practically throughout the length of both claims (3,000 feet) and probably into the Gray Eagle. The ore has been proved 800 feet below the highest point of the vein. The west or foot-wall is definitely known Low grade ores.

but the hanging wall or what may correspond to it has not yet been reached. One stope is 21 sets wide and 100 sets long (7 feet centres), which will furnish some idea of the size of the ore-body.

(*b*). Bodies of more or less lenticular form, generally occurring in groups or as ore chutes, in vein-like bodies as in the Brooklyn and Stemwinder, and B.C. mines.

(*c*). Smaller veins.

Ore-forming minerals.

According to the chief economic minerals in them, these deposits may be subdivided into a pyritic type, in which pyrrhotite, chalcopyrite with some pyrite are the chief economic minerals; and a magnetitic type in which magnetite, chalcopyrite with some pyrite and specular iron are the chief minerals. Excepting that the pyrrhotite of the one is represented by magnetite in the other, these two types appear to be identical. Both the magnetite and the pyrrhotite replace the constituents of the country rock in the same way; both seem to have been formed, on the whole, a little prior to the other vein minerals, holding them in little veins or as points scattered through, yet sometimes interbanded with them. They are both accompanied by the same accessory and gangue minerals and the country rocks show the same alterations in both cases. Rarely do both the pyrrhotite and magnetite occur in the same deposit. In the Old Ironsides and Mother Lode, pyrrhotite is, however, present, and in one or two small veins, as on the O. P. and Wolverine claims, both are found. The B.C., Maple Leaf, Winnipeg, Lake and Morrison, may be mentioned as representatives of the pyritic type, while the Knobhill-Ironsides, Mother Lode, Sunset, Brooklyn, Snowshoe, Oro Denoro, Emma and R. Bell belong to the magnetitic type.

It might be remarked that this pyritic type has not yet been found in such large masses as the other, but that the magnetitic type is common in all forms.

Besides the metallic minerals already mentioned, marcasite is occasionally present and, rarely, arsenopyrite, galena, zinc blende and molybdenite, but these are in all cases subordinate in quantity. Tetrahedrite has been found in the City of Paris, and bismuthenite occurs in a specimen obtained at the Bluebell.

Metasomatic replacement.

The ore, for the most part, has replaced the country rock (metasomatic replacement). On the outskirts of an ore body this substitution can often be seen in all stages of development, the individual constituents of the country rock being one by one replaced. The mineralizers

must of course have followed fractures in the rock, or the line of contact between two rocks when more than one rock is present, and these have also been filled with ore, but the main development of ore has been in the rock itself. Sometimes a fracture-plane, sometimes an impervious rock such as a dyke of diorite-porphyrite or a contact of compact crystalline limestone will form a containing wall to the deposit, but very often there is nothing resembling walls, the ore being irregular in form and gradually shading off into country rock. From the nature of the bodies, altered country rock will form the gangue-stone. In the alteration of the rock, garnets, epidote, amphibole, tremolite, vesuvianite, may be produced and the rock may in addition be silicified and calcified. The calcite occurs well crystallized, in large masses, in little seams or disseminated through the ore and rock. It is seldom found in those parts of a deposit in which magnetite is heavily concentrated. Quartz is often abundant, occurring in the same way as the calcite. Silicification of the country rock to a cherty or quartz-like (jasperoid) mass is a frequent, though not invariable phenomenon in the neighbourhood of a deposit. Garnets, epidote and amphibole are very abundant in and near the deposits. They occur both well crystallized and massive, often interbanded with the ores and forming a large percentage of the material mined.

Paragenesis.

All the minerals in the deposits appear to have been formed almost contemporaneously. They are often banded. Where there is a slight difference observable, the minerals like garnet and epidote are often formed first and the magnetite or pyrrhotite before the pyrite and chalcopyrite, but the periods of formation of the different minerals in all cases overlap. The minerals are not evenly distributed, but while sometimes mixed are often bunchy. Magnetite and calcite seem to be inversely proportional—where magnetite is plentiful calcite is sparse, and *vice versa.*

The rocks mineralized.

The ore may occur in any of the rocks except the Tertiary, and even the Tertiary sandstone or tuff, underlying the lavas south of Copper creek, shows some mineralization. The deposits are most numerous, are largest and most valuable in those parts of the district most disturbed by Tertiary volcanism. Limestone in such cases seems favourable for the deposition of ores. In a few instances the ore occurs in the limestone itself, but more frequently it is found in a rock along its contact with limestone. The old porphyrites, or porphyrite-tuffs, breccias or conglomerates (which we will refer to, collectively, as 'greenstone') are the commonest rocks in such cases.

Limestone as country rock.

It is only fair to state that several eminent observers have considered the greenstones to be altered limestone, and have consequently concluded that a characteristic feature of these deposits is their occurrence in limestone. Emmons holds this view, although he recognizes the pyroclastic nature of the Ironsides rock* Since the rocks are usually altered and the minerals produced are those common in metamorphosed limestone, it is natural that without a close study these rocks should be considered altered limestones. That they are not altered limestones but altered volcanic and pyroclastic rocks is established by detailed field study and the examination of thin sections. Moreover, it is found that the limestone becomes white or crystalline, with some silicates developed, but is not, as a rule, subject to the same degree of alteration as the greenstones, and that thin bands and tiny inclusions of it in the greenstones preserve their identity, even when that rock is greatly altered. Hence it is usually an easy matter to establish the boundaries of a limestone mass, and it is found that the limestone masses while very conspicuous and somewhat numerous are, as a rule, of very limited extent.

Limestone contacts favorable.

The contact between limestone and the porphyrites or pyroclastic rocks seems, as observed above, to be a favourite location for the deposition of ores, and in such cases the ore seems to have a distinct preference for the greenstone.

The lack of mineralization in the limestone may be due to the fact that the limestone apparently often flows and forms compact lenticular masses, instead of fracturing under pressure, and thus furnishes no channels for the mineralizing solutions. If attacked and replaced by them it must have been along the contacts and this must have taken place comparatively evenly, leaving a clean-cut unmineralized wall.

In the case of large deposits along such a contact, it may be difficult to prove which rock is replaced. The fact that clean ore lies along unchanged white limestone, the limestone forming a well defined wall, while the ore and gangue minerals wander off and disappear without any line of division in the greenstone, would make it appear that the greenstone was the rock which suffered greatest replacement. But in many cases, as in the Snowshoe and the B. C., the original structure of the porphyrites or pyroclastic rocks can be seen in the ore. But the strongest evidence of the selection by the ore of greenstone rather than limestone along a contact is obtained in small deposits, where the alteration has not obliterated the actual contact. In such

* Genesis of Ore Deposits, 2nd edition, American Institute of Mining Engineers, page 760.

cases it is the greenstone and not the limestone which is most altered and replaced.

The fact that epidote, amphibole and garnets are developed in the ore is no proof of the contrary, for these contact minerals are developed in all the older rocks—granodiorite among the others, and apparently less readily in the limestone than in the other rocks.

Garnetized granodiorite.

On the south side of Pass creek the solid granodiorite is altered in places to solid garnet. The garnets commence to form in the granitic rock from a number of centres, sometimes with a core of granodiorite as a nucleus, and around these centres develop with crystallographic outlines (M.O.M.), generally distinctly zonal. The growth is continued till all the intervening rock between the centres is converted into garnet. That the material for the formation of garnet and epidote was to some extent at least, brought in by mineralizers and did not depend on the country rock is shown by their occurrence in quartz-filled fissure veins in different rock in this district. The Mother Lode which occurs near a limestone contact, may lie wholly within the limestone. The 'gangue' to a considerable extent is a felt-like aggregate of little actinolite fibres, unlike the usual 'gangue' of these deposits. *Emmons decided, after a microscopic examination, that it is altered limestone. Its contact with the white crystalline limestone is fairly sharp and distinct, but this is not the case in other directions. Ore is found in the crystalline limestone without the green alteration products, but it must be admitted that the ore formation was not always later than that of the contact minerals. That the contacts between limestone and other rocks should be favourable may have been due in part to the chemical influence of the lime in precipitating the mineral contents of the solutions, but it was also due to the lack of firm cementing between the limestone and the contact rock, which left free channels that the solutions used as highways and bases for their operations. But while such contacts are favourable, mineralization is by no means confined to them. In fact in the largest deposit yet found in the district (Knob hill-Ironsides), with the exception of an insignificant island of it, found on the intermediate level, limestone is conspicuously absent, although it occurs at numerous unmineralized points in the vicinity.

Contacts favour mineralization.

Ore also occurs in the other Pre-Tertiary rocks; the City of Paris mine is in serpentine, the Winnipeg in granodiorite and serpentine. Large masses of low-grade sulphides occur in the granodiorite between Brown and Pass creeks. In conformity with the principal structural featuresthe ore deposits oftenest lie about N. and S. with an easterly dip.

The ore bodies as contact deposits.

From the foregoing brief description of some of the leading features of these copper deposits it will be seen that they are characterized by irregular and indefinite forms, and by the association of such minerals as garnets, epidote, amphiboles, etc., with sulphides of iron and copper, oxides of iron, with a little molybdenite, arsenopyrite, etc., all of which minerals are primary in the ore. These characters are peculiar to deposits formed by the contact action of eruptive rocks. When an eruptive rock, as a molten mass, forces its way into solid rocks, its effect upon them may be of two kinds. It may cause a re-arrangement of the material of the country rock into characteristic new minerals without altering the chemical nature of the rock. This is largely the effect of heat and therefore is confined to the actual contact between the intrusive and the country rock, being most intense at the contact and gradually fading away from it. A second effect may be to alter the chemical nature of the country rock near and along the contact. This is effected by means of the vapours and liquids the molten rock-magma contains and which are given off when the rock solidifies or reaches the surface. These vapours and liquids are strong mineralizers; they contain chemical reagents derived from the molten rock. This kind of contact action (pneumatolytic) is not as dependent as the former upon the actual contact of the eruptive for its intensity, for the gases and liquids may wander into the country rock along fractures and fissures and do their work there. Consequently, while often found along the actual contact, the 'pneumatolytic contact zone' may be found as islands in the neighbouring country rock. It is to this class of deposits that the low-grade Boundary ores belong.

Somewhat similar deposits, though on a much smaller scale, of magnetite and chalcopyrite occur at * Cherry Bluff, Kamloops lake, near what Dr. Dawson considered a volcanic vent. These have no doubt been formed by volcanic after-actions.

† In the Cristiania district, Norway, magnetite and specular iron, together with the sulphides of copper, zinc, lead, etc., occur within the metamorphosed zone of eruptions, especially of granite, though as far as 2 kilometers from the actual contact. In association with them are contact minerals similar to many in the Boundary district. These deposits are explained by Vogt and others as the result of contact metamorphism and pneumatolytic after-actions.

‡ Lindgrun in a recent paper on the subject of contact deposits gives some United States examples of this same type of deposit.

---

* Annual Report Geol. Surv. Can., vol. VII. (N.S.), 1894, p. 341B.
† Zeitsch. für Praclt. Geology, 1894, pp. 177, 464; 1895, p. 154.
‡ Trans. Am. Inst. Min. Engineers, vol. XXXI. and Genesis of Ore Deposits, 2nd edition, p. 716.

If these deposits have been formed by contact action they must be connected genetically with some eruptive rock or rocks. At first sight it appears as if the granodiorite might have been responsible for their formation. It outcrops at a number of points, covers a considerable area near the principal ore bodies, sends numerous dykes through the country, and evidently underlies most of the district at no great depth. If it were responsible for the mineralization, ore should not be found in it except in contraction joints near its contacts. Ore, however, is found in it apparently independent of its contact and contraction joints. Moreover, in the Tertiary conglomerates and tuffs overlying the older formations no fragments of ore could be found, although carefully searched for, but they are themselves mineralized to a slight extent. Hence the granodiorite cannot be responsible for these contact deposits.

Relationships of granodiorite.

As remarked above, the ore bodies are particularly numerous and large, and have better values around vents, and intrusions of the Tertiary eruptives. The greater number of the smaller bodies are beside and parallel to alkali-syenite porphyry dykes. This is so frequently the case that the relationship can scarcely be accidental. It is true that a large number of these porphyry dykes appear to cut and be nearer than the ore bodies. While this proves that the ores were formed before the close of volcanic activity, it does not prove that they were not formed during the period of Tertiary volcanism. The alkali-syenite magma sent out a number of systems of dykes with a time interval between. On Lower Arrow lake the same magma has given birth to almost a dozen such systems with a sufficient time interval between for the preceding system to cool before the next appeared. Volcanic vents plugged with basic rocks occur between the Knobhill-Ironsides and Stemwinder on the west and the Snowshoe on the east. The hill on which Mineral Monument XVIII. stands, near the Emma, Oro Denoro, and not far from the B.C. mine, is another vent similarly plugged. No vent was discovered near Deadwood, but the volcanic flows cover so much of the country in this neighbourhood that the chance for finding one, if it were there, is slim. The tuffs show that there must have been one not far away, and the rocks in this neighbourhood are profoundly altered. It is perhaps worthy of remark that all the large deposits lie immediately under the capping of volcanic lavas, though in some cases these have been entirely removed by erosion. It is reasonable to suppose, therefore, that these deposits and the Tertiary eruptions are genetically connected, and that, therefore, they are of Tertiary age.

Relationship between the Tertiary eruptions and the deposits.

The ore bodies, like the volcanic rocks, show evidences of movement since their formation; numerous slips, some with "gouge" or secondary

Movements subsequent to ore formation.

filling traverse the ore bodies. This broken nature of the ground, coupled with the original irregularity in the form or the ore body, and the severing of the deposits by dykes, makes the exploitation of the smaller deposits sometimes difficult and precarious. The slips so far encountered have not been sufficiently large to have seriously affected the larger deposits. The serpentine is particularly full of slips, some prior but many subsequent to the formation of the ores, which make it probably the least satisfactory country rock in the district.

A striking feature in the deposits is the lack of surface oxydation or alteration. At most, a few feet below the surface of the ground the ore exhibits the same characters as are found in depth. The soil overlaying a deposit is often quite unstained, offering no indication of the underlying ore, and consequently adding to the difficulties of prospecting ; sometimes the surface of the ore even retains the glacial polishing.

On the Knobhill the surface of the ore is in places fluted and striated like a mass of Laurentian granite.

Values.

The values in the ores are principally in copper and gold, sometimes with accessory silver. Further study is required to formulate the laws governing the distribution of gold values. Generally magnetite and pyrrhotite when occurring alone are almost barren, yet this is not always the case. In the Knobhill-Ironsides the massive magnetite is said to have a gold value. This is said to be the case on the Seattle claim, but in an assay of this magnetite made for the writer no gold was found, though the accompanying chalcopyrite was auriferous. In the Winnipeg mine pure pyrrhotite carries as high gold values as have been found in the mine, but at other points in the same mine barren pyrrhotite is found. Chalcopyrite occurring in magnetite and pyrrhotite is generally a gold carrier, but the gold value of an ore does not always increase with the copper percentage. Thus in the Mother Lode the best gold values are said to be found where the ore holds about 2 per cent. of copper. In the B. C. mine the gold is said to be confined to the chalcopyrite—pyrite and pyrrhotite being barren. On the other hand, in the Brooklyn, Stemwinder and Rawhide the best gold values are reported from the pyrite and specularite ores. So far as could be superficially observed, the local opinion that the intersection of veins or stringers with the main bodies does not cause an enrichment, seems to be supported by the facts. It may be noted that where dykes cross the ore bodies there appears in some cases to be an enrichment of the ore. Possibly there may prove to be a relationship between the quartz and the richness of the ore. Though segregated in places, the chalcopyrite is on the whole remarkably evenly

distributed through even the immense deposits. In the Knobhill some bodies richer in copper run transversely through the lode. The magnetite is not evenly distributed. In the Knobhill 'Glory-hole,' a band of magnetite 15 feet wide runs parallel to the deposit. In the Ironsides below the Knobhill magnetite is almost wholly absent.

Away from the chief centres of mineralization, while magnetite and pyrite are still found, copper and gold are only sparingly present.

These ores as a rule are of very low grade, lower than was at first hoped. This has been counterbalanced by the size the bodies have shown in development and their remarkable adaptability of the ores to smelting. The magnetite, quartz and calcite are present in the ore in such proportions that, at most, only a little judicious mixing of the ore from different parts of a mine is necessary to produce a self-fluxing product for the smelter. When quartz is a little scarce it can be supplemented by ore from the gold and silver-bearing quartz veins of the district or by silicious ores from Republic camp, across the International Boundary line. Sulphur is so low that no roasting is required. Ten or eleven per cent of coke only is required so that the cost of smelting as well as of mining is exceptionally low.

A member of the Dominion Copper Company kindly granted permission to publish the following figures regarding the contents of the ores of this company, which are more or less representative of the ores of Greenwood camp.

Gross Returns.

SiO_2	39·00 per cent.		
CaO	17·00 "		
FeO	14·00 "		
Cu	1·95 "	=39 lbs. Cu (at 10c. per lb.)	$3 90
Au		·119 oz	2 40
Ag		·44 oz	0 22

Net Returns.

Cu	$3 10
Au	2 40
Ag	0 22
	$5 72

Dr. Ledoux, of the firm Ledoux & Co., New York, through whose hands the output of copper from the district has passed, gives the following information concerning the values of Boundary creek ores.*

*Journal of the Canadian Mining Institute, Vol. v, 1902, p. 174.

The ore from the north side of the Phœnix ravine is estimated to run 1·80 per cent. copper, $2.40 gold, 25 cents silver per ton. The workable ores from the south side of the Phœnix ravine contain on an average, copper 1·70 per cent, gold $1.60, silver 33 cents per ton.

The ore from the east side of the volcanic vents (Snowshoe, Gold Drop, &c.) 1·60 per cent copper, $1.50 gold and 30 cents silver per ton. The run of mines in Greenwood camp as shown by smelter returns is probably 1·60 per cent copper, $1.80 gold and 50 cents silver. He estimates that the low grade ores of the whole district will run from 25 to 35 lbs. copper, 25 to 40 cents silver and from $1.50 to $2.50 gold per ton of 2,000 lbs.

(The B. C. mine near Eholt runs a good deal higher in copper.)

Costs. The cost of mining is estimated to be from $1.60 to $2.10 per ton, the former being the cost more recently. The cost of smelting must be considerably under $2, and the freedom of the ores from arsenic, antimony and bismuth makes it easy to obtain a market for the copper. The total cost of mining and smelting must be under $3.60 per ton. Dr. Ledoux's estimates agree pretty closely with the information which has been given us.

Values as high as $30 per ton are reported on car lots of ore from the Winnipeg mine, and $20 on shipments from the Humming Bird, the B. C. ore also runs high, but such values are exceptional in the sulphide ore-bodies and the deposits are bunchy and small in comparison with the typical deposits of the district.

Method of mining. The method of mining adopted is a combination of open quarrying, and the pillar and stope system below ground, similar to that followed in the large iron mines. A description of the method, by Mr. Keffer, was published in the Journal of the Canadian Mining Institute*. The ore in the quarry is usually dropped through an uprise from a tunnel on the level of the ore bins where it is loaded into cars, the large blocks of ore being first reduced by 'bull-dozing' with dynamite or being reduced by an immense crusher.

On the Knobhill the quarrying is to be done in benches, the lower bench being on a level with the railway so that cars may be run in and loaded directly. It is proposed to install steam-shovels for handling the ore, to further reduce the cost of mining.

Permanence of the deposits. An important question in regard to these deposits is their permanence and character in depth. Unfortunately, it is one that cannot be

* Vol. 5, 1902, p. 213.

definitely answered. This kind of contact action extends to great depths, and an ore-body formed by it may have a great vertical dimension but in the majority of cases in other districts the mineralization is bunchy and irregular and not restricted for a great distance to one plane, though it may be continued along a second plane not far from the first. In the Boundary district the problem is further complicated by the intrusive dykes.

In the B. C. mine below the 400 feet level these become so numerous that it is not worth while following the lead farther, as the proportion of waste rock to be handled would be too great.

Extent of ore bodies.

The work on the best developed claims, Mother Lode and Knobhill-Ironsides shows that these deposits have a considerable vertical extension, and nothing is known of their limit in depth, which may possibly be below the lowest limit for profitably mining such ores. If the plug of brown porphyritic rock east of the Knobhill has vertical walls the ore body with its 45° dip will strike it in depth and cut off this part of the lead. This volcanic plug has not, on the surface a northerly extension, so that it is probable good ground will lie between it and the volcanic plug which lies just north-west of Phœnix station.

The smaller deposits are generally bunchy though often a number of ore masses lie within a small area.

The character of the ores may be expected to remain unchanged, although possibly sulphur may become a little more prominent. Since these deposits show no surface alterations the values are not likely to lessen while the other conditions remain unchanged.

If, as there is good reason for believing, these deposits are of approximately the same age as the Tertiary eruptives, then it is almost the original surfaces of deposits that are at present exposed and being worked, for as they are immediately under the volcanic rocks, very little of the deposits can as yet have been eroded. It will be interesting to see, if with depth, they do not contract, with perhaps a concentration of values.

Description of the Mines.

Knobhill Ironsides mine.

It is impossible within the limits of the present report to give a detailed description of each mine. That will be done in the final report, but a few notes on some of the principal mines will be given here to add definiteness to the above general description of the low grade copper ores of the district.

Greenwood or Phœnix Camp.

Knobhill-Ironsides Mines.—The Granby Consolidated Mining, Smelting and Power Co., Ltd., own and operate these mines. The following claims owned by the company lie in and south of the Phœnix ravine: Phœnix, Fourth of July, Old Ironsides, Knobhill, Victoria, Ætna, Gray Eagle, Banner, Tip Top and Triangle Fraction.

The ore deposit as developed lies about magnetic N. and S. running through the Old Ironsides, Knobhill and into the Gray Eagle. Its dip is 45° thus carrying it under the Victoria and Ætna claims.

Nature of country rock. The country rock is principally the old green volcanic breccia with bands of tuffs and ash, locally known as diorite. The fragments are of chert, argillite, porphyrite and limestone with a few of granite. A little limestone is encountered at the north end of the intermediate level of the Old Ironsides. A dyke of the gray granitic diorite-porphyrite may form part of the 'gangue,' but it is too much altered to be identified with certainty. But it is found on the north side of the ravine and the structure of some of the altered rock, forming the gangue, resembles that of the diorite-porphyrite. On the Knobhill spur, a little east of the ore bins, and forming the foundation of the new compressor plant, is a white granular, even-grained Tertiary tuff, consisting largely of quartz and feldspar fragmemts of uniform size. It is locally known as 'porphyry.' It occurs interbanded with beautifully laminated cherty ash beds. This rock extends south-westward up the hill to the Gray Eagle, but is pierced by a somewhat circular plug of brown porphyritic rock which might be called basalt. The white tuff at the contact has been melted to a glass for a fraction of an inch, and the rock of the plug has a less highly crystalline selvage which resembles the reddish alkali porphyries. This is no doubt the filling of a local volcanic vent. On the higher ground to the east, dark grayish or purplish andesitic lavas form a capping over the tuff and Pre-Tertiary rocks. These lavas extend across the railway at the station, but are there pierced by a second volcanic vent plugged with a rock similar to the first. Grayish, reddish and pinkish alkali syenite porphyry dykes are common in the neighbourhood, but the only dyke seen in contact with the ore was at the north end of the lead. The western limit of the ore body is well defined but the eastern has not yet been determined, nor has its extension in other directions been definitely established although the development work done on the property no doubt exceeds three miles. (On March 21, 1902, it was calculated to be 14,771 lineal feet.) The material mined consists of magnetite, chalcopyrite, pyrite, specularite, pyrrhotite, calcite, quartz, garnets, epi-

dote and hornblende together with less highly altered country rock. In the Knobhill quarry or 'Glory hole' magnetite is concentrated in a band at least 15 feet wide, through which the copper and iron pyrites are scattered. The band runs parallel to the lead. On the Ironsides the ore is mixed with a great deal of calcite, and magnetite fails. It seems as if the calcite and magnetite alternate with each other in these ores.

The ores from the different parts of the mines are sorted into three bins as :—I. Ordinary ore-rock—garnet, calcite, hornblende, magnetite, copper and iron pyrites. II. Calcareous ore—rich in calcite and poor in magnetite. III. Ferruginous ore, rich in magnetite. No. III. comes largely from the Knobuill and II. from the Ironsides.

East toward the Victoria shaft, where the ground was being stripped by ploughs, scrapers and aerial carriers, the ore uncovered contained a good deal of quartz. At one place the silicious band was separated from the ordinary ore by what appears to be a slip. The equipment and method of mining are described in the report of the Minister of Mines for British Columbia, 1901.* A 60-drill compressor, and two 700 h. p. electric motors are being added to the plant. The output from the big quarries and immense stopes is limited only by the smelter's capacity.

Brooklyn-Stemwinder mines.

Brooklyn–Stemwinder Mines.—These properties, lying on the north side of the Phœnix ravine, belong to the Dominion Copper Company. They have had a considerable amount of work done on them, but have been closed down the past year. The country rock is the old green pyroclastic, containing a great many fragments of limestone, with some of quartz, porphyrite and ash material interbanded with limestone.

A dyke of diorite-porphyrite occurs to the west, and many pink alkali porphyry dykes occur in and near the ore bodies. The ore is altered rock containing chalcopyrite, pyrite and specularite. In the Brooklyn, the ore body, which is about 25 feet wide, occurs along, but not in the limestone, which seems to form a containing wall for the ore. This is the statement of the late manager and it agrees with what we saw in the field and in microscopic slides. In the Stemwinder, three courses of ore are supposed to occur. While development work has revealed large bodies of ore, apparently not enough has been blocked out to warrant the erection of a smelter, and the tariff for custom smelting is a great tax on those low grade ores.

* For particulars as to development and equipment of the mines consult the Reports of the Minister of Mines for B. C.

Snowshoe mine.

Snowshoe.—Owned and operated by the Snowshoe Gold and Copper Mines, Ltd.

The conditions here are somewhat similar to those obtaining at the Knobhill-Ironsides, except that the ore-body as explored is smaller though still of immense size. The country rock is the old green volcanic conglomerate or tuff, whose character is distinctly recognizable where not too much altered by mineralization. A lens of gravel-holding crystalline limestone occurs along the west side of the ore-body. A little above it on the Gold Drop, the capping of lavas mentioned above in describing the Knobhill, is exposed. Some dykes of porphyry and dark lamporphyres cut the older rocks. Although 7,000 feet of development work has been done, besides a good deal of diamond drilling, more will be necessary before very definite statements can be made regarding the form of the deposit or deposits. The contour of the surface of the claim seems to conform roughly to that of the deposit, but the latter is more undulating. The ore along its western boundary is dipping eastward, and on its southern boundary it is pitching northward. At its north end at the old shaft the dip is southerly, so that it would appear to form a rude basin. There appears to be a second parallel ore-body. The determination of the form and limits of ore is complicated by the numerous slips, some with much gouge showing that there has been a good deal of movement since ore deposition. Some of these appear to have brought unmineralized rock against ore. The mineralization itself is not regular, horses of rock appearing in the ore. The ore consists of chalcopyrite, magnetite, specular hematite, pyrite, quartz and calcite with some epidote, garnet and serpentinous material. The minerals of the ore are not evenly distributed. Magnetite often occurs in bunches, some parts of the ore are highly silicious and others very calcareous. At the outskirts of the ore-body, as at the south end, stringers of calcite with bunches of ore, sometimes solid chalcopyrite, follow fissures in the rock. The values occur principally in the chalcopyrite; magnetite bears a little gold and silver, while the hematite and pyrite are almost barren. No pyrrhotite or arsenopyrite has been found.

The method of mining is the same as that adopted in the other large properties. The high pressure half, of a 30-drill compressor is being installed to supplement the 5 and 7 drill compressors already in use. Two 80 horse power boilers are being put in, in addition to the 70 horse power boiler already at the mine.

Deadwood Camp.

Mother Lode mine.

Mother Lode Mine.—Owned by the British Columbia Copper Co., Ltd. The group of claims include the Mother Lode, Primrose, Off-

spring, Tenbrock, Don Julis and Sunflower. Mining has been confined to the Mother Lode, but it ranks next the Knobhill-Ironsides as the largest and best developed property in the district. In many respects the deposit resembles the other large ore bodies but it has several features of its own. As in the majority of cases its strike is nearly north or south (a little east of north), and its dip is eastward 55° to 70°. It outcrops at intervals for about 2,000 feet, but is only developed north of the shaft, located about the centre of the deposit. Where explored, its width averages perhaps 140 feet, but its boundaries are somewhat indefinite. The ore is continuous to the 300 feet level, the deepest workings, which are some 500 feet below the highest outcrop of the deposit. More than one ore shoot occurs. On the 300 feet level two are well defined. The minerals occurring in the ore are magnetite, chalcopyrite, pyrite, with a very little zincblende, galena, pyrrhotite and an occasional trace of arsenopyrite, calcite, actinolite, garnet, epidote and quartz. (The ore and rocks of the Mother Lode have not yet been studied microscopically and cannot be described definitely). No specular hematite has been found. The ore like that of Phœnix camp is divided into three classes: Special features.

I. Silicious, made up of the various silicates of calcium, magnesium, aluminum and iron with massive and disseminated copper and iron pyrites, and a little zincblende. Nature of ore.

II. Calcareous calcite and quartz with copper and iron pyrites, sometimes massive, sometimes finely disseminated. Near the wall in the 200 feet level, this ore has some argentiferous galena and blende.

III. Ferruginous ore, consisting of fine-grained magnetite with quartz and chalcopyrite.

These three classes of ore often occur separately but are sometimes mixed. A large mass of magnetite occurs at the entrance of the mule tunnel and several bands of it occur in the west side of the deposit, apparently dipping west. The silicious ore often differs from the Phœnix ores in the amount of fibrous actinolite it contains, and the ores as a whole contain more magnetite. They also differ in not carrying hematite.

The three classes of ore are said to have the composition given in the following partial analysis*.

	I. Silicious.	II. Calcareous.	III. Ferruginous.
Silica	44·23	20·10	27·33
Alumina........	7·46	1·31	....
Iron oxyde.........	16·83	12·00	51·12
Lime and magnesia	16·03	34·00	10·26
	84·55	67·41	89·71

*British Columbia Mining Record, May, 1902, p. 173.

The silicious ores carry a little silver as well as gold and copper. The blende and galena are argentiferous. Magnetite and pyrite, as a rule are not auriferous, but in the Keffer stope the magnetite carries gold. The chalcopyrite when present in such quantities that the ore holds 2 per cent of copper, seems to be the best gold carrier, but when nearly pure, running 30 per cent copper it carries no gold. The ore along the porphyry dyke carries rather better values than elsewhere. The rock on the west of the ore body forming the foot wall, is an apparently very pure white crystalline limestone. It dips south and east, bending round and cutting off the ore at the north. It has been encountered on the 200 feet level but has not yet been found on the 300 feet. The rock on the east is a green fissile epidote-like material that is said to have the same chemical composition as the ore, except that the metallic minerals fail. Across the ravine to the south the rock appears to be argillite. To the north of the lead the rock is greenstone-tuff and conglomerate, and these greenstones appear to surround the mass of limestone which has no great dimensions. All these rocks, especially to the north, are heavily dyked by the pink alkali-syenite porphyries, and on the surrounding heights, and occasionally in little basins on the slopes, the Tertiary lavas are found. A heavy dyke and one or two smaller ones, of alkali porphyry run through the ore body nearly at right angles, lying almost horizontal but with a low dip to the south and west.

The limestone contact is generally somewhat sharply defined, but it shows a little irregular alteration and some of the metallic minerals occur sparingly in the pure crystalline limestone along the contact. The rock to the east is too much altered to be identified with the unaided eye, but it is likely to prove to be altered argillite. It is likely that the western part of the ore is altered limestone, while the eastern may be altered argillite. No limestone is found in the ore body. It may be stated that the lime in the ore always occurs either combined in the silicates or as calcite scattered through the ore, like the other constituents. At the north end of the deposit the altered epidote-like rock overlies ore on the surface and has to be stripped off before quarrying can be done. Recent stripping at this north end has revealed a fine body of good grade ore.

On the lowest level the ore body seems to be altering its dip as if to become parallel to the porphyry dyke. But further work is necessary here before the shape of the ore body can be intelligently discussed.

Sunset mine.

Sunset Mine.—The Montreal and Boston Copper Co., Ltd., owns this claim together with the Crown Silver, lying between the Sunset and Mother Lode, the C. O. D. and Florence fraction. A two-compart-

ment shaft has been sunk on the Sunset and one shaft 260 feet deep on the Crown Silver, and considerable work done, especially on the Sunset (in the neighbourhood of 5,000 feet). The ore body above the 100 feet level has been opened up ready for stoping. It has a width of 115 feet and it is estimated there are 250,000 tons of ore ready to be taken out. Only a few special features in connection with this mine will be mentioned.

On the foot wall the rock is altered to almost pure silica. It appears to have been either the greenstone tuff or argillite. In places it is brecciated; the pebble-like fragments are embedded in serpentinous matrix. Going into the tunnel from the S. E. on the 100-feet level, after a few feet of silicified and slightly pyritized rock, a heavy slip is encountered which runs N. and S.; angle about 50° W., and west of this is solid magnetite ore with some pyrite or chalcopyrite scattered through it. Sometimes the ore is banded. A solid band of pyrite at least 4 feet wide occurs separated from the ordinary ore by two feet of crushed country rock. Foot-wall an altered rock.

The magnetite sometimes occurs in rosette-like aggregates resembling hematite. Quartz occurs as blebs through the ore; calcite is scattered through it and occurs as stringers. Actinolite and epidote sometimes occur in the magnetite. The lower levels were not examined, as the mine was closed down at time of our visit owing to the strike of coal miners at Fernie. A specimen of marcasite was shown me, said to occur in a vein cut on a drift from the 300 feet level, running towards the Crown Silver. It is said to contain $30 a ton in gold. An ore shoot of sulphides several feet wide with good gold values is said to occur on the 200 and 300 feet levels, which will be used to increase the grade of the 'run of mine.' Alkali porphyry dykes are found running through the ore body, but they are usually small and have no apparent effect on the ore. They have a distinct salband, but their walls are sometimes slickensided, showing that the country rock has moved along them since their formation. Gold contents.

Here, as elsewhere, the ore body shows the effects of earth movements since the ore was formed.

Summit Camp.

B.C. Mine.—This mine is owned by the B. C. Chartered Company, Ltd., which also owns a number of claims in the vicinity. B. C. mine.

This mine possesses peculiarities which deserve noting. The ore body occurs on a contact between white crystalline limestone

and greenstone, too much altered to determine whether porphyritic or pyroclastic. In thin sections the porphyrite structure can be seen, but this might be a fragment, and north along the wagon road to Eholt, a short distance from the mine, the tufaceous character of the rock is distinct. South, in the south-west corner of the basin in which the mine lies, the compact porphyrite occurs. Dykes of diorite porphyrite, somewhat the worse for wear, occur in these rocks, one just west of the dining-hall. The exact form and extent of the limestone mass cannot be made out, partly owing to covering of drift and partly owing to the alteration which it has sometime undergone.

It appears to be a lenticular mass lying north and south in the greenstone, extending from about the railway spur north of the shaft house, to a point on the hill-side, 200 paces south of the south prospect shaft.

Main ore body.

A large mass of limestone occurs on the hill at the head of the basin, and along the ridge between the B. C. and Rathmullen creeks. Toward the north end of this ridge are greenstone tuffs and conglomerates, extending westward across B. C. creek. These are capped by Tertiary lavas and sheets of alkali porphyry and are much cut up by dykes and intrusive sheets of the latter rock. The main ore body of the B. C. is a lenticular mass, lying about north and south, with a slight easterly dip. It is 65 feet wide and about 200 feet long, but contracting along both dimensions as it goes downward. It is very much cut up by intrusive sheets of alkali porphyry which form regular floors in the lode. There are two sets of these sheets, one a coarser grained reddish porphyry with biotite crystals in addition to numerous feldspar crystals, and a later, light pinkish set, with no visible crystals except those of feldspar. Both sets have distinct salbands against the ore, but the ore does not appear to be affected by them, being continuous from one sheet to the next one below and so on down. It has, however, a platey jointing parallel to the sheets, along which the ore falls readily away. This plating may be due to heating by the dykes and subsequent contraction.

Depth of mine.

The ore is mined to 400 feet, below which the sheets become so heavy and numerous that it would not pay to extract the ore. Other ore shoots on the lead are being tested by surface workings. Sufficient ore has already been taken out to have made the mine a success.

Several diamond drill holes have been run from the 400 feet level, one to a depth of 511 feet below. While a considerable amount of ore was gone through, even to the bottom of the hole, a large proportion

of the core was of alkali porphyry. Toward the bottom of the hole a good deal of granodiorite was cut through, as though this rock occurred *en masse* at no great depth below.

The ore consists of chalcopyrite, pyrrhotite and a little pyrite, with the following gangue minerals—garnet, quartz, calcite, and magnesium carbonate, epidote, zoitite, actinolite, chlorite, serpentine, plagioclase, and probably kaolin. Nature of ore.

This gangue is in part at least altered greenstone, as the structure was retained in a microscope slide. As the limestone, though rather sharply defined, shows some alteration and garnetization, it may form part of the gangue. Garnet is probably the most abundant gangue mineral.

A little specular hematite and zincblende occur on the outskirts of this ore body. The walls are merely "commercial walls."

A fault parallel to the ore body runs through porphyry and ore with no great vertical displacement.

About 200 feet south of the shaft house an open cut shows a contact of the white crystalline limestone and the altered garnetiferous rock. The division between the two is sharply defined.

The values are considerably above the average for the Boundary district, principally in copper. The average assay for the ore shipments to the end of 1901 is said to be: copper, 5·8 %; silver, 2·45 oz.; gold, ·015 oz. per ton. The best values have been obtained when the ore body is constricted.

In addition to the mines described, considerable work has been done on a great number of properties, in some cases with encouraging results. In Deadwood camp may be mentioned—Morrison, Marguerite, Greyhound, Ah There, Buckhorn; in Phoenix camp—Gold Drop, Rawhide, Idaho, War Eagle; in Wellington camp—Golden Eagle, Winnipeg, Athalston; in Summit camp—Emma, Oro Denoro. Other claims.

Sulphide deposits, sometimes of considerable size, also occur outside the areas described, as between Brown and Pass creeks, also eastward to the North Fork. These have never advanced beyond the prospect stage, either on account of the grade being too low, or where the grade is satisfactory, on account of the ore being bunchy or through lack of capital. It is possible that valuable deposits will yet be opened up in these parts of the district. Southward and eastward from the main

centre of mineralization, these deposits seem to gradually lose their distinctive character and grade into sulphide-bearing quartz veins, often with well crystallized garnets and epidote in the quartz. Most deposits of this class are as yet merely prospects.

Some of the deposits in Central camp may belong here. The City of Paris is the most prominent property in this locality.

City of Paris mine. The rocks in this camp are black argillites with intercalated lamellæ of quartz, large masses of serpentine intrusive in the argillites, and dykes and bosses of diorite-porphyrite. Cutting these rocks are more recent porphyry and lamprophyric dykes. The rocks are much shattered and altered. The mine is on a steep side-hill. A tunnel about 1,000 feet long has been run in to the lead, from which drifts run N.W. and S.E., along the lead. These are connected with two shafts to the surface. The rock at the entrance of this tunnel and for several hundred feet in, is an altered gray porphyrite rock, probably altered granite-porphyry or diorite-porphyrite. Its general dip and the dip of its joints is about N.E. Joints or slips in it are filled with little stringers of quartz and calcite. Beyond this altered porphyry is serpentine, very much dissected by slips and fractures.

The lead runs about N. 22° W., and varies in width from mere stringers of ore to 15 feet.

Cross cuts. From the north-west drift along the lead four cross cuts have been run 90 feet. The rock traversed by them is impregnated with and traversed by stringers of quartz and calcite carrying sulphides, which diminish in amount with the distance from the main lead. In one cross cut an ore body was encountered running S.W., or diagonally to the main lead. The ore occurs in chutes. A dark dyke occurs in the mine with ore following it on each side.

The ore on the north-west drift consisted of argentiferous galena, blende, tetrahedrite, chalcopyrite and pyrite, while on the south-east drift the ore is almost massive pyrite and chalcopyrite. The ore from the north end of this mine was sent to the lead smelter at Trail, that from the south to the Granby smelter at Grand Forks.

Values. The values are said to be unevenly distributed, running in pay streaks. The tetrahedrite gave very high assays. The mine has been idle for the last year and a half, pending, it is said, increased transportation facilities.

II. Oxydized Copper Veins.

These are found in Copper camp at the head of Copper creek. They occur in the Pre-Tertiary rocks along the lower border of the Tertiary lavas, which in thick sheets lie as a capping over the older rocks. Oxydized copper veins.

A short description of the King Solomon claim will illustrate this type. This deposit is met with at a contact between a dyke of alkali porphyry and crystalline limestone. Wedge-shaped tongues of the porphyry extend from the main dyke into the limestone. Both the limestone and the dyke are much fractured and traversed by little slips. These fractures cut the limestone into small blocks. In the limestone, and to a less extent in the fractures in the porphyry, along the contact, are deposited various oxydation minerals of iron and copper, including native copper. These embrace red massive and earthy hematite and yellow limonite, crystallized and massive malachite and azurite, a black amorphous substance, containing copper oxide (melaconite), lampadite and chalcocite, cuprite, often in transparent crystals, native copper, chrysocolla and probably copper-pitchblende. The edges of the small limestone blocks have often been dissolved and the copper ores then occur as incrustations surrounding a core of lime. The main fissures are filled with the iron and copper minerals, the smaller principally with the copper. In the porphyry it is only the fractures near the contact which contain a thin film of copper ore, the rock itself remaining fresh and unaltered. About 650 feet from the main working on the King Solomon is a small vein. The rock is here not so badly shattered. On the surface, carbonates and other copper minerals with iron oxides are found ; a little below the surface the sulphates of these metals occur, and below these unoxydized pyrite and chalcopyrite begin to appear. What can be seen to be taking place here on a small scale is probably what occurred on the King Solomon ledge (proper) on a much larger scale, so that this type of deposit is probably an oxydized and secondary enriched form produced by the action of surface waters of a sulphite deposit, similar to the first type of Boundary deposits. The iron of the sulphides has been removed or redeposited as hematite and limonite ; the copper has been more or less concentrated in the form of various oxydized minerals. King Solomon claim.

The Big Copper claim, a little to the north of the King Solomon, on which some work was done this summer, affords additional information regarding this type of deposit. Big Copper claim.

An open cut was run in on the lead 88 feet. The course is about 311° at first but bends round to about 264° (astronomically). The dip

is N. at a high angle. The foot wall is crystalline limestone of convex form, which constricts the vein from a width of 20 feet at the top of the cut to a width of 6 or 7 feet at the floor. The hanging wall contains some garnet and may be altered greenstone tuff, but it is too decomposed for identification. A dyke of porphyry similar to the King Solomon occurs in the hanging wall. The limestone near the vein looks like an agglomerate with a green matrix containing quartz and other material in pebble-like particles. The matrix is mineralized to some extent, but the limestone is not. Until this is studied, it cannot be affirmed that this matrix is not an alteration of limestone along fractures.

The surface of the vein is altered to a red earthy hematite, which paints everything around; below this is chalcocite in masses a foot square; this can be seen giving place to bornite and the latter to chalcopyrite. Specimens can be gathered showing a nucleus of chalcopyrite surrounded by a zone of bornite, and a periphery of chalcocite. A little native copper and copper carbonate occur near the surface. Evidently surface waters have leached out copper on the surface of the deposits and this descending on the vein, and coming in contact with the iron-bearing chalcopyrite, the copper they contained has been precipitated or has replaced the iron of the pyrite, thus enriching the ore finally to chalcocite, after the manner already described by Emmons and Weed.*

The best grade ore is found in the vein overlying the limestone. The ore is said to run 15 per cent in copper, and to carry $4 in gold and 9 oz. in silver per ton. The hematite extends up the hill to the base of the lavas. The depth to which the vein is oxydized and the value below this zone can only be determined by additional work on the deposit.

Copper camp zone of oxydation.

That a zone of oxydation and enrichment should be found in the veins of Copper camp and not elsewhere in the district may in part be explained by the local topography, and the broken nature of the country rock, but the chief factor, in all probability, has been the capping of the volcanic rocks which covers the hill-tops all around and extends almost to the King Solomon and other of these deposits, the deposits occurring underneath their lee. In pre-glacial times these rocks are likely to have extended a little farther, in which case they would have protected the deposits from the scouring effects of the ice-sheet. In addition, the contact between the volcanic and older rocks is likely to be a natural waterway.

---

* Genesis of Ore Deposits, 2nd edition, Am. Inst. Min. Engineers, page 433. Trans. Am. Inst. Min. Engineers, vol. XXX. Bull. Geol. Soc. Am., vol. IX., 1900. page 179-206

The basalts lying above these deposits carefully tested by Mr. Macneil of the School of Mining, Kingston, have been found to contain no trace of copper.

III. Gold and Silver Veins.

These are found on the outskirts, or between the areas in which the large low grade deposits occur. They are found filling fissures and replacing the country rock along fissures. In their relationship to the rocks of the district they are similar to the deposits of type I. There is nothing to show that they are not of the same (Tertiary) age. The gangue is generally quartz with some calcite, and in one or two veins near Hardy mountain, siderite.

Economic minerals.

The economic minerals are chalcopyrite, pyrite, galena, blende, tetrahedrite; sometimes rich silver minerals as ruby silver, argentite, native silver, with in some cases tellurides and native gold. The veins vary in width from a few inches to several feet. To illustrate this type of deposit three of the best developed veins will be briefly described:—

Jewel Mine.—Situated in Long Lake camp, about eight miles from Greenwood and four miles from Eholt.

Situation of Jewel mine.

The mine is upon a contact between the gray biotite-hornblende granodiorite and a green schist, which, however, is generally dark green in this vein through development of biotite. As it has not been studied microscopically its original nature is still in doubt. The granodiorite is developed extensively to the south and west, the schists extend northward and across Long lake, but are very heavily cut by alkali porphyry dykes, which, on Roderick Dhu mountain, form the principal rocks. Dykes of this porphyry occur in the mine as well as small dark lamprophyric dykes.

The vein runs about N. and S., with a dip of about 45° E. (The Jewel shaft has a dip of 39° 30′ east). For the most part, as at present developed, granodiorite forms the foot wall and schist the hanging—that is, the ore occurs along the contact, but on the south it is in the granite alone, and it is sometimes found in the schist. The granite contact is not altogether regular, as tongues of it run into the schist. The vein varies in width from 2 to 12 feet with an average width of say 4 feet. Horses of country rock occur in it, often filled with ramifying veinlets and blebs of quartz, so that there has been replacement as well as fissure-filling. The vein is considerably cut up by the porphyry and lamprophyric dykes. A large dyke of porphyry which is

Dykes.

exposed on the surface at the engine house, runs E. and W. and dips north at an angle of about 50°. It is also encountered in the 120′ and 230′ levels. It seems to cut the ore. In the south extension of the 230′ level it has a salband against the ore, but the sulphides are in contact with it and some quartz blebs occur in the porphyry. The ore at this point becomes disseminated in numerous stringers through the rock, which is mineralized for a width of 30 feet. There appears to be a heavy fault here, as the ground is much broken up and a tongue of the massive granodiorite is reduced to a gravel-like mass. The long tunnel to the north is in ground full of slips, with stringers and bunches of quartz running in all directions. This is in schist, a little to the east of the granodiorite contact. It may be that the compact granitic rock has had a mechanical effect in concentrating mineralization, whereas the mineralizers were more disseminated through the schist. One dyke 4 feet thick occurs a few feet below the 120′ level, dipping 30° to the west. It throws the ore 8 to 10 feet east—a normal fault. A lamprophyric dyke encountered north of the shaft dips southward. It crosses the 230′ level north of the shaft and the 300′ south of it. It appears to have affected the ore, rolling it back on the 230′ level. There are numerous small lamprophyric dykes, some only an inch or so wide, running continuously from level to level. These dykes cut the ore and are therefore later. The larger ones fault the ore, generally to the east, in normal faults. Faults later than these dykes have also affected the ore body. Some are parallel to the ore and form a secondary wall, with gouge. That these are not original walls is proved by their faulting the later dykes. Unless the faulting has brought up unmineralized country rock, ore may therefore be found outside them.

Such a relationship between ore, dyke, fault and secondary wall can be seen in the stope south of what is known as the 'extension.'

In one instance, along the footwall, the vein has been brecciated by movement, forming a band 8 inches wide of rounded and angular fragments of quartz in a greenish white matrix, separated from the solid ore by gouge. It is altogether probable that there has been considerable replacement as well as fissure filling. The granitic rock, as well as the schist, has little veinlets in it near the ore body. Following the vein northward along the surface a heavy dyke of porphyry, perhaps 300 feet wide, is encountered, which runs E. and W. It appears to fault the vein considerably, as ore is found on the north side 275 feet to the east. On this vein about 1,000 feet from the main shaft, in a direction 10° E. of north, is a second shaft, down 150 feet, known as the Rowe shaft. The shaft is inclined 53° 30′ eastward, and follows

the vein to between the 100′ and 150′ level, when a porphyry sheet cuts through. It appears to fault the vein, as on the 150 feet level, a drift a few feet long had to be run east to catch the vein. A quartz vein is found on the Enterprise, Ethopia and other claims to the north, which appears to be the northward extension to the Jewel vein. The ore is quartz, containing galena. pyrite and chalcopyrite. In the upper part of the vein some free gold and rich tellurides are found. The amount of sulphides and the values vary greatly from place to place in the vein, and no rule governing the distribution has as yet been discovered.

The walls are mineralized for a short distance from the vein, the hanging wall as a rule having better values than the foot wall, giving from $1 to $3 a ton for two feet or so from the vein. The galena carries the best values; pyrite is also rich. Chalcopyrite is likewise valuable, but there is very little of it in the ore. Solid galena is said to have assayed $300 in gold per ton. Solid pyrite assayed $57 in gold. Some silver is also present. The ore as mined is said to yield from ten to twelve dollars per ton. If a method of successfully concentrating the ore can be secured the future of the mine should be bright. Some calcite in veinlets occurs in the ore and in fractures in the dykes, so that it is probably of later formation than the vein. A mineral which appears to be sericite is developed in the quartz to a limited extent, and the formation of mica in the schist seems to be the result of the agents of mineralization. Gold contents of ore.

Providence Mine.—Situated one mile north of the town of Greenwood. Though one of the first claims located, and though 45 tons of ore shipped by pack train in the early days netted a handsome profit, very little work has been done on the property. The reason seems to have been that the vein, after following the shaft for a distance, began to dip away from it at a considerable angle. This discouraged the operators and about the same time quartz veins went more or less out of fashion in the district, the low grade deposits receiving the attention. Recently Mr. Fowler, a prospector, took over the claim, followed the vein where it dipped out of the shaft, and now the prospect gives promise of becoming a profitable little mine. The rock is greenstone or greenstone tuff, along a contact with granodiorite; the vein, however, so far as developed, is in the greenstone. At the entrance to the open-cut the granodiorite is exposed. Next follows a 10′ east and west dyke of porphyry and then the greenstone. The vein seems to bend eastward along the north side of the porphyry dyke. The vein in the open cut strikes 21° (mag.), dipping 60° to the eastward. At and between the two shafts its course is 40° (mag.) The dip is 60° southeast. About 10′ below the surface in the shaft the vein pinches and Providence mine.

flattens for a short distance, when it pitches down and widens once more. Its width varies from 8 inches to 4 feet, with an average width of rather more than one foot. The vein then is not uniform in direction, dip or width. Some slips occur, faulting the vein a foot or 15 inches eastward.

Description of ore.

There is some replacement of the wall rock, the greenstone being silicified and pyritized, and traversed by tiny veinlets. The ore is white, rather watery quartz, often crystallized or with a tendency to crystallize, containing calcite, galena, zinc blende, pyrite, chalcopyrite, with some tetrahedrite, chalcocite, ruby silver and argentite, native silver and gold. A little sericite seems to be developed in the quartz. The galena occurs in masses an inch or more in diameter, with zinc blende. Tetrahedrite is found through the galena and the quartz. Chalcopyrite occurs in this quartz in particles up to ½ an inch in diameter. The chalcocite, the rich silver minerals and the native silver and gold occur generally in films around quartz crystals or in small crevices and cracks through the quartz or in the small masses of gray calcite contained in the quartz. This occurrence of rich minerals in films in secondary cracks in the ore shows that there has been secondary enrichment, and that both silver and gold have been carried in solution and precipitated. This solution has probably been effected by surface waters. Not enough work has been done to determine the depth to which this enrichment extends.

The galena and tetrahedrite are both very rich in silver and have good gold values.

The 45 tons shipped in the early days to the Tacoma smelter are said to have yielded 200 oz. of silver and 6¾ oz. of gold per ton.

Since work has been resumed shipments have been made which have also yielded high returns. A shipment in August gave about $145 per ton.

Not enough work has been done to show the relationship between the vein and the porphyry dyke. As stated above, where exposed the vein bends east along the porphyry. If the porphyry does not cut the vein, the latter is almost certainly of Tertiary age.

No. 7 Mine.—Owned by the No. 7 Mining Co., Ltd., of New York, situated in White's or Central camp.

The vein occurs on a contact between serpentine on the west and black argillites on the east, and on both sides are light and dark porphyritic dykes.

The vein which varies from 18 inches to 7 feet in width, runs N. W. by W. It dips 53° E. to the 60 feet level and then flattens to 45°. On the footwall and forming a wall to the vein are several small black dykes, too decomposed for determination, and these are of great assistance in mining. In the hanging wall is a dyke of gray syenite porphyry. In the prospect tunnel 250 feet east of the shaft house this cuts the vein and faults it with a throw of 5 feet. On the 60 feet level it also cut the ore and a tongue of it divides the vein into two branches. A second dyke of apparently the same rock cuts through it and everything else. The course of this second dyke is S. E.; dip about 50° S. W. A dark micaceous dyke 20 feet wide also cuts the vein. The vein is occasionally found completely in the serpentine. The ore is quartz, carrying galena, a little blende, a little pyrite (possibly marcasite) chalcopyrite and tetrahedrite. The ore is often banded. On the 200 feet level, east drift, the ore has some bands of country rock lying in it, so that replacement has occurred here also. The galena carries silver values and the pyrite gold values. The ore assays from $7 to $60 per ton. As shipped it runs probably from $10 to $15.

The mine has been developed to the 300 feet level. In July shipment and work were suspended on account of the difficulty of transportation.

Quartz veins are numerous in the vicinity of Greenwood and between July creek and the North Fork of Kettle river. They occur in all the Pre-Tertiary rocks. With typical fissure veins replacement of the country rock is generally somewhat pronounced. Some of them have been developed with satisfactory results, some are too poor to work, while others seem to have lost values below a shallow zone of secondary enrichment. In general they have not received the attention that might have been expected or that they deserved.

Other materials of economic or possible economic importance in the district.

Platinum.

Platinum—In the report of last year the writer called attention to the possibility of platinum being found in the district and neighbouring parts of British Columbia. The reasons for expecting platinum in this part of British Columbia are:—1. The widespread occurrence of basic eruptive rocks, now mostly altered to serpentine. It is in such rocks that platinum has been most frequently found, and so far as is known, the platinum of placers has been for the most part derived. 2. The similarity in the geological conditions here and in the Similkameen district, where the most productive platinum placers in North America are located. 3.

The resemblance between the chalcopyrite-pyrrhotite ores of this part of British Columbia and those of the Sudbury district, where these ores carry sperrylite—the arsenide of platinum. It has recently been reported as occurring in the copper ore of the Rambler mine, 60 miles from Laramie, Wyoming. In a *Bulletin on Platinum by J. F. Kemp, just issued, the author gives the results of his investigations on the occurrence of platinum in the Similkameen. He found platinum to occur in quantities varying from traces to nearly 2 oz. per ton in sepentine bands in altered peridotite. It was also detected in dykes of pyroxenite in the peridotite, and probably as a secondary mineral in an altered granite.

During the past summer platinum was found in Burnt Basin, about 15 miles east of the present sheet, in a gold-bearing quartz vein, on the Mother Lode claim belonging to the Contact Consolidated Mines, Ltd. Samples of the ore were sent by the manager, Mr. Henry P. Jackson, of Rossland, to Baker & Co., Newark, N. J., for assays. These yielded results varying from traces to 0·25 oz. per ton. In a sample of Mother Lode ore brought in by the writer and assayed by Mr. Manly Baker, of the School of Mining, Kingston, platinum was obtained but not weighed. In similar samples, Mr. D. Locke of this department obtained results varying from traces to 0.1 oz. per ton. The quartz carries free gold, near the surface at least, and chalcopyrite, pyrite, galena, blende and molybdenite. It occurs in dark schistose rock which is probably altered porphyrite cut by syenite porphyry dykes, and a basic syenitic or gabbroitic rock. Nearby are limestones and gray granite. Veins of galena and blende occur in the limestone in the vicinity.

Tin.

Tin.—Is reported to have been found near Long lake, but no information could be obtained regarding the exact locality. It is quite possible that traces may occur in connection with the intrusions of granitic rock in that part of the district. But no alterations of these rocks were observed, such as take place where tin occurs in commercial quantities.

Coal.

Coal.—In the clastic and pyroclastic rocks of Tertiary age, underlying the volcanics some small lenses or bands of coal are found. West of Midway, outside the sheet, a bed is of sufficient thickness to have attracted attention, but nothing worthy of note was found in the Tertiary rocks of the Boundary Creek Sheet.

* Bulletin of the U. S. Geol. Survey, No. 193—Geological Relations and distribution of Platinum and associated metals. J. F. Kenp.

Petroleum.—Borings for oil are being made on the banks of a pond just west of Observation mountain, near Grand Forks. Since the rocks are all crystalline or igneous, of very complicated structure, the discovery of oil in any quantity would be entirely opposed to all past experience in the occurrence of mineral oil. So far oil has been found to occur where there is organic material present to furnish the hydrocarbons, a porous rock present to retain the oil, and an anticline or some such structural feature which would furnish room in which it might collect. None of these conditions are present in this district. Petroleum.

Clay.—Clay suitable for brick-making occurs in the neighbourhood of Grand Forks, on Eholt creek, Lind creek and elsewhere. Brick clays.

Serpentine.—None of the serpentine seen was sufficiently massive to be useful as an ornamental stone. In White's camp a very pure soap-stone occurs which, near transportation and a market would have an economic value. In the same locality some fibrous serpentine occurs (chrysotile asbestos). None of the fibres seen possess the requisite quality for commercial purposes. Serpentine.

Building Stones.—The granodiorite of Greenwood is quarried as a building stone, for which on account of its jointing and quality it is well adapted. Some of the syenite porphyry dykes exposed on the railway cuts would make good building and ornamental stones. The Tertiary tuffs and sandstones where accessable as at Phœnix and near Midway, would also make good building material. Building stones.

Marble.—Some of the crystalline limestones are sufficiently massive and pure to make good ornamental stone, but they are not always accessible. Many are also suitable for burning into lime. Marble.

The occurrence of clay with these limestones would make a cement industry possible if there should ever be an available market. Cement.

HINTS TO PROSPECTORS.

Since there is a great deal of similarity between the geological conditions in the Boundary district, and those of other parts of South-western British Columbia, so far as they are known, it is quite likely that the experience gained in the Boundary Creek district may be applied in the districts west of it. Some of the results of observations in the Boundary district may be summarized as follows :—

Ore may be found in any of the Pre-Tertiary rocks where conditions for mineralization were favourable.

Conditions under which mineralization has taken place.

The chief condition for mineralization appears to be heavy Tertiary volcanism. Ore occurs, (1) near vents through which the volcanic rocks reached the surface; and (2) where the country rock is extensively dyked by the pink or gray alkali-syenite porphyry. Limestone contacts in such areas should be prospected with particular care.

On account of the irregular form which the ore bodies may possess and the complex nature of the rock formations, a careful and detailed study of the surface of the ground in the neighbourhood of the mines would be of great practical assistance in the exploitation of the ore bodies. For the same reason development work must always be kept well ahead of the actual mining. Cross-cutting must frequently be resorted to, to determine the actual limits of the deposits, and to prove the existence or non-existence of parallel ore shoots. The limits of mineralization must be actually proved, and similarly, only that ore can be with certainty reckoned on which has been actually blocked out. In this connection diamond-drilling can be resorted to with advantage.

Magnetic methods of prospecting.

Prospecting by means of magnetic surveys might sometimes be successful, so far as the magnetitic and pyrrhotitic ore-bodies are concerned. Since much of the surface is drift-covered, and the ore-bodies do not as a rule have any oxydizing effect on the soil above, this is often the only way in which any indication of the spot where a test pit should be sunk can be obtained. It might also be applied in searching for ore-bodies in the mines themselves. It has not yet been attempted in this district.

Where the ore occurs at a limestone contact, the limestone wall may often be used for following the ore, it being kept in mind that the ore does not always follow strictly along the contact, and that the limestone may pinch out without causing the ore to likewise disappear. The dykes in some cases may be used in the same way.

The pyrrhotite and magnetite should always be assayed, as barren-looking material may carry good pay values. The minerals in the ore and the conditions where pay values occur should be carefully studied with a view to ascertaining which minerals carry the values, and what were the causes which produced the concentration of values. The porphyry dykes themselves, while not mineralized in the same way as the country rock, may in places prove auriferous. In a specimen from a similar alkali-porphyry dyke, from the Valkyr mountains, east of Lower Arrow lake, examined last winter, free gold as a primary constituent was plainly visible, even with the naked eye.

Since, with the exception of certain deposits in Copper camp, there is no zone of oxydation and secondary enrichment in the large deposits, while the general conditions remain unchanged, no loss of values is to be expected in depth.

Platinum should be tested for in the copper ores and in the quartz ores. Gravels of streams draining areas of serpentine should be panned for platinum. In places the nuggets are sometimes brown or lead-coloured, but become silvery white when treated with nitric acid. The serpentines themselves, especially where containing chromite (a magnetite like mineral), might be assayed for this metal. Platinum.

In the oxydized type of copper deposit a zone of enriched sulphides occurs between the oxydized minerals and the pyrites. Below this zone of enrichment the deposit may or may not have sufficient values to pay for working. Sufficient work has not been done to determine the lower limit of the zone of enrichment.

The quartz veins merit more attention than has been given them.

In prospecting, it is to be remembered that float may have been carried a considerable distance, even across valleys, by former glaciers. The general course followed by the latter was about S. 30° E., but it was influenced by the local topography.

PRODUCTION.

While a little high grade quartz ore was shipped from the district by pack train, ore production may be said to have commenced in 1900, after the completion of the Columbia and Western railway into the district, and of the Granby and Greenwood smelters. Since that time the approximate tonnage shipped and smelted is as follows :—

Mine.	1900*.	1901*.	To Nov. 30, 1902.	Approximate. output for 1902†.
	Tons.	Tons.	Tons.	Tons.
Knobhill-Ironsides	64,531	231,762	280,601	310,601
Mother Lode	5,564	99,548	122,577	137,577
B. C	19,618	47,517	11,627	14,627
Golden Crown	2,241	......	625	625
City of Paris	2,000	......	......	......
Winnipeg	1,076	977	785	785
Snowshoe	297	1,731	15,540	20,800
Athelstane	1,200	550	......	......
King Solomon	......	850	......	......
No. 7	......	665	532	532
Sunset and Crown Silver	......	800	6,750	8,010
Jewel	160	325	2,175	2,175
R. Bell	......	480	......	......
Brooklyn	150	......	......	......
Ruby	......	85	......	......
Emma	......	......	6,700	7,900
Providence	......	......	132	172
Small shipments	1,000	500	158	158
Totals	97,837	386,675	448,602	503,962

* Minister of Mines Report for British Columbia, 1901.
† Engineering and Mining Journal.

The production for 1902 will exceed the total previous yield, in spite of the fact that a shortage in coke, caused by the Fernie strike, necessitated the closing down of the smelters and mines during part of July and August, and that lack of power at the Granby smelter, due to exceptionally low water, has, all fall, prevented the smelter from running full blast. Practically all the ore produced is treated in the smelters of the district. Since the completion of the branch of the Great Northern Railway through Grand Forks to Republic, some Republic ores have also been shipped to the Granby smelter for treatment.

Smelters.

There are three smelters in the district:—the Granby at Grand Forks, the B. C. Copper Co.'s at Anaconda (Greenwood), and the Montreal and Boston at Boundary falls. These plants are modern and first-class in every respect. The Granby smelter has a sampler of 2,000 tons per day capacity, four furnaces with a capacity for these ores of 380 tons daily each, a briquetting plant for flue dust and two converters with all the necessary and accessory plant. Electric and hydraulic power operate numerous automatic and labour-saving devices. The matte from the other Boundary smelters and from the Hall Mines smelter at Nelson, is sent here to be converted to blister copper. It is proposed to increase the plant by two more furnaces.

B. C. Copper Co.'s smelter, Greenwood: The plant consists of ore bins, sample mills and two 2,300 ton furnaces, arranged on a gravity system so as to require a minimum of energy and labour. During January, one 300-ton furnace smelted on an average 428⅜ tons of ore daily, with a record run of 460 tons of ore in 24 hours. From these figures the remarkable adaptability of Boundary Creek ores to smelting is readily perceived as well as the skill with which the smelting operations are conducted.

The Montreal and Boston Copper Co., have taken over the Pyritic smelter at Boundary falls to treat their ores from the Sunset and Crown Silver. This smelter, which was built for pyritic smelting, was never operated as such, and has now been fitted up for ordinary smelting. The plant consists of one large furnace and a sampler. A second furnace is contemplated.

BRIEF HISTORY OF THE DISTRICT.*

The first man in the district was Charles Dietz of the Riverside Hotel, who came in, in 1857; 'Old Jolly Jack' Thornton, who still resides in a cabin on Boundary creek, was the second man. Boundary

* Most of the statements herein made are based on information supplied by John East, one of the early pioneers.

creek was worked for placer gold, in 1862, a small town being located south of the International boundary line. In 1884 the first mineral claims in southern B. C. were staked, the Victoria and Washington, afterwards Old England, located on Rock creek a few miles above Kettle river. The same year two of the pioneer prospectors, John East and W. T. Smith came to the Boundary creek district, and in 1885 they located the first claim in the district, the Rocky Bar, now the Tunnel, on Boundary creek near the falls. The same year they also located the Non-such in Smith's camp. First location.

In 1886 the Bruce claim on Ingram Mount was located by East.

In 1887 George and David Leyson and Geo. Y. Bowerman located the Big Copper, as the Blue Bird. They went on through to Trail creek, where they made some locations around what is now Rossland, but they allowed their claims to lapse. The King Solomon was located by Lefabre and Lynch, who threw it up. In 1888 it was acquired by D. C. Corbin. In 1890-91 there were some locations made by James Attwood and John Lemon around the Buckhorn. On May 23, 1901, the Mother Lode was staked by William McCormick and Richard Thompson, and on June 2, John East located the Sunset and Wm. Ingram located the Crown Silver.

The same summer the pioneer prospectors crossed over to what is now Phœnix. Matthew Hotter located and named Knobhill. Attwood located the Brooklyn and Summit camp. Scott McRae, Geo. Taylor, Henry White, Geo. Rumberger and others also made locations, White and Attwood, in particular, locating White and Attwood's camps. The Providence was located in 1891 by Dickman.

In 1892 Howard C. Watters brought in a 2-stamp mill, which was set up at Boundary falls to treat the quartz of Boundary falls and American bay claims. The Providence shipped about 45 tons of ore, which is said to have netted $15,000. The Skylark is said to have shipped $25,000 or $30,000 worth of ore. Interest in the low grade ore bodies in the early days is said to have been awakened by Scott McRae, who made a trial shipment for outside capital, and by E. P. Sudam, who sampled the ores and brought in outside mining men. The town site of Midway, formerly known as Eholts, was acquired by Capt. R. C. Adams and associates of Montreal, in 1893. The site of Greenwood was acquired in 1895 by Robert Wood, who immediately founded the town. Grand Forks was one of the earliest settlements. On the advent of the Columbia and Western railroad most of the camps sprang suddenly into incorporated towns. The chief towns of Stamp mills.

the district are Grand Forks, Eholt, Phœnix, Greenwood, Anaconda and Midway, with small settlements at Deadwood, Boundary falls and Carson.

Present population.

The population of the district is supposed to be in the neighborhood of 10,000. The chief industry on which practically all the others depend is mining. The attendant industries and occupations are fully represented. Lumbering is carried on to some extent and ranching is becoming important. It is found that the lower valleys are admirably adapted for fruit growing, and apples, plums and strawberries of prime quality are now being cultivated. The mining camps and towns afford a good market for all such produce.

Geology of the Western Part of the International Boundary (49th Parallel).

Dr. R. A. Daly.

I left Ottawa on May 27 and joined the Boundary Survey party under Mr. W. F. O'Hara, D.L.S., at Greenwood. Active field work was begun on June 5 and, owing to the unusually favourable weather this season, continued with but few interruptions until the middle of October. My field expenses were, as last year, paid through Mr. King, our Chief Commissioner, by the Department of the Interior, but the wages of my assistant, Mr. F. Nelmes, were this season paid by the Geological Survey Department. The geological work of the summer was divided into two parts corresponding to different sections of the Boundary belt traversed by our party. The following sketch is a brief business report of the work done, embodying a few preliminary and general considerations on the areas covered.

Reconnaissance work.

During a rapid journey from Midway to the Similkameen river Mr. O'Hara collected information additional to that secured last year for the completion of the topographic map of that section. In this way I was enabled to have a preliminary view of its geology; material was gathered which will be of value in a future more detailed geological examination. Three weeks were thus devoted to the reconnaissance of this section of the Boundary country. The belt measures 43 miles in length by from 4 to 5 in breadth; a greater width could not be covered because of the fact that the main camp, to which I was attached, was often compelled to locate on or south of the line, while it seemed best to concentrate attention to the Canadian side so far as my own work was concerned.

Topography west of midway.

The whole belt lies within that division of the Cordilleran Mountain system called by Dawson "The Interior Plateau"; it is situated between the Coast (Cascade) range on the west and the complex, rather indefinitely bounded Gold ranges on the east, and forms that zone of the Rocky mountain region of the least strength of relief. In the 43-mile section examined this season the altitudes of the highest summits rarely exceed 5,000 feet above sea-level. The deepest valleys are those occupied by Osoyoos lake and the Similkameen river at its eastern crossing of the 49th parallel of latitude. The lake is almost exactly 1,000 feet above sea-level, and the river is at approximately the same altitude. The average elevation of the higher ridges and rolling hills of the belt is not far from 4,500 feet above sea-level.

The whole of the topography is the immediate product of long continued denudation which has gone considerably further than in the coast range studied last season. In this central part of the Cordillera the alpine horns, serrate ridges, amphitheatres, etc., are absent and, in their stead, the relief is composed of an irregular assemblage of old mountains, low domes, sugar-loaf forms and ridges of relative tameness in aspect, all rounded into the profiles characteristic of mountains that have long suffered erosion by streams and as long suffered loss during the slow but sure streaming of rock debris down the slopes. These slopes are thus of the type called 'graded,' *i.e.*, they are generally of a degree of steepness whereby the loose material weathered off from the bed-rock can assume the form of long, smooth slopes of waste mantling the hills from top to bottom. Bare rock-surfaces in such topography are much less common than in truly alpine, younger mountains.

Relation of topographic developmens to mining.

An important consequence to both the geologist and the prospector is found in the comparative inaccessibility of the bed-rock, covered as it is by the waste. The study of rock-distribution and structure as well as the discovery and exploitation of mineral deposits are, for this reason, more difficult in such mountains than in those characterized by ungraded, alpine slopes. This general fact must never be forgotten in estimating the economic importance of the Cordilleran zone, now called the 'Interior Plateau.' It is, for example, highly probably that the Similkameen district will repay much initial expense in boring for coal even where the prospector has but few outcrops of the coal or its associated formations to guide him in the development. In other words, the few natural exposures of mineral-bearing strata, veins, etc., in 'graded' mountains are worthy of specially energetic study by miners and government surveyors, more for what they indicate concerning mineral deposits buried under the adjacent 'wash' than for their own particular mineral contents. The economic development of the

'Interior Plateau' must, therefore, be relatively slow and expensive, but, as it becomes settled and intelligent prospecting continues, it may prove to be as rich in mineral resources as any other part of the Cordilleran region.

Evolution of the topography.

From the experience gained on the reconnaissance, rapid as it was, I am forced to consider it as inadvisable to describe the region as part of a 'plateau.' Such a name would imply that the area once formed a portion of a more or less continuous, flat-topped or gently rolling, elevated tract, and that the existing diversity of relief is the effect of erosion acting through a long period of time on that block of high land. Such is the view advanced by Dawson for the 'Interior Plateau.' His evidence for it was derived from the study of the northern part of the same mountain-zone lying on either side of the main line of the Canadian Pacific Railway (of the Kamloops sheet and corresponding report by the late director of this Survey). The preparation of the simple, flattish surface of the 'plateau' in this zone of enormous structural complexity is ascribed by Dawson to the prolonged erosion of the crumpled Palæozoic and Mesozoic strata composing a once lofty range. In this way, provided time enough were allowed, an almost perfect plain of denudation (a peneplain) would be produced. Strong bodily uplift of the denuded area would, then, by the theory, give the elevated 'plateau.' On its surface the streams would be given renewed power to lower their channels, deep and narrow at first, deep and flaring open later on in geological time. To such activity of streams in a second 'cycle' or era of denudation, Dawson attributed the great and small valleys sunk in the 'plateau,' and in accordance with his theory, the second period of erosion was responsible for nearly all the existing diversity of relief in the extensive 'Interior Plateau.'

Along the International boundary, however, the evidence for two such cycles of denudation is but slight. The chief positive criterion for the previous existence of an undissected plateau underlain by truncated strata folded and faulted by mountain-building, is the discovery of remnant areas of that plateau not destroyed by erosion. Such remnants seem to fail entirely between Midway and the nearest outlier of the coast range, the Okanagan mountains. The mountains have not the broad, flat tops expected, but are generally of conical or ridge-shaped form, such as belongs to a range worn down in one cycle of denudation. The accordance in altitude of the summits is far from being perfect, and such accordance as does exist can be explained by other conditions of mountain sculpture. Further study of this topo-

graphy will be facilitated when Mr. O'Hara's final topographic map of the belt is completed.

In the glacial period, the Cordilleran glacier, moving southwardly between the Coast range and the wall of the Gold ranges, completely covered the highest summits in the belt. The result has been to disturb the pre-glacial mantle of rock-waste which lay on the old mountains. The loose rock-material was, however, not carried far, and it is probable that the amount of such material now resident in the belt in the form of boulder-clay, stratified glacial gravels, sands and clays, is at least as great as before the ice moved over the country. The field observations agreed in showing an enfeebled erosive activity of the great glacier in this part of its course. Its terminal moraines are not far to the southward across the Boundary line, and the great abundance of drift and but slightly modified pre-glacial rock-waste indicate that the glacier was depositing its load of débris rather than scouring off the products of weathering from the rock-surfaces whence they were derived. The conditions recall the useful parallel that has been made between glaciers and rivers. At the lower end of each the geological work consists chiefly in deposition ; a delta corresponds to terminal and ground moraines. Added to the evidence of slight glacial erosion as indicated by the deposits, is that derived from the fact that well-developed roches moutonnées, striated, grooved and still firm, are notably rare.

Glaciation west of Midway.

The glacial veneer of rock-detritus thus left on even many of the summits as well as in the valley bottoms, often corresponds in depth, continuity, and surface configuration to the pre-glacial veneer of weathering products expected from the secular decomposition of the different formations of the belt. Access to bed-rock and prospecting for mineral deposits are therefore almost as difficult as if the country had never been glaciated. Compensating in some degree for this disadvantage, perhaps more than compensating for it, the veneer of decomposed rock-matter, often affording rich, strong soils, will more and more prove to be a valuable asset to the country, since full varied crops can be grown upon the veneer, not only in the valleys, but often far up towards the summits of the intervening mountains.

As in most glaciated regions, the glacial sands, gravels and till of the valleys have been extensively terraced by the respective streams. Fine examples of such terraces were seen along the west fork of the Kettle river. Both there and elsewhere in the belt, excellent illustration was found of the influence of rock-spurs from the adjacent mountains in preserving the terrace-deposits as they may now be seen.

Stream-terraces.

These spurs have controlled the meandering of the streams in such fashion as to restrict the width of the meander-belt more and more as the streams have cut down their channels. The upper terraces have, for this reason, not been undercut and destroyed in the later swings of the meandering streams. Excellent farm land has been preserved thereby and it forms a considerable part of the economic resources of the region.

Terraced alluvial cones. An interesting special feature of this channel-sinking is illustrated at many points in the belt, but again best of all in the valley of the Kettle river near Midway. Large, more or less symmetric and regular alluvial cones or steep-slope fans of rock-detritus have been washed out of the terrace-sands from lateral gorges. As the main river to which the drainage of the gorges is tributary, swings to the foot of one of these cones, the cone may be partly cut away and thus truncated, and the 'base level of erosion' of its perennial or wet-weather stream is lowered and the cone cut away by that stream. Dissected cones regularly terraced by the repetition of this process are well displayed along the almost treeless valley-walls of the Kettle and other rivers. Just north of the town of Midway, a young, inner cone has been built up in the deep, flaring notch of a terraced older cone since the time when the Kettle river swung away southward to its present position. The whole complex form shows how sensitive are the degradation and 'aggradation' of alluvial material to changes in the position of the base level of erosion.

Geology west of Midway. Until the topographic maps of the boundary belt surveyed this season are finished, it is impossible to present a report of enduring value on the distribution and structure of the solid rock formations met with. The reconnaissance of the belt from Midway to the Similkameen river resulted in the recognition of at least five chief divisions of its rocks. Oldest of all is a group of crystalline schists, mica-gneisses, mica schists, granites and granitoid gneisses occurring on the shores of Osoyoos lake. These are of great but unknown age, older than a second division of rocks also enormously plicated, cleaved and broken in the stress of mountain-building. This second group is composed of phyllites, slates, quartzites, chloritic schists and amphibolites with highly altered greenstone and true volcanic bands. Certain lenses of crystalline limestone are also provisionally referred to the same great series. Throughout its extent, but more especially in the phyllitic and slaty members, quartz veins, often of huge size occur, but so far, they have proved to be practically barren of the precious metals. This thick and important series of rocks outcrops at intervals

from the meridian lying about seven miles west of Midway nearly to the Similkameen. No fossils were discoverable.

Unconformably overlying the metamorphic group are outliers of Tertiary sedimentary rocks; light and dark gray sandstones, grits, conglomerates and shales, all greatly disturbed and so much destroyed by erosion as to represent but a small part of the once thick and continuous formation, doubtless at one time covering the entire belt. Leaves and stems of exogenous plants of Tertiary habit were found in the sandstones of a long monoclinal section on the wagon road about four miles west of Midway; and again in the gulches tributary to the Kettle river near the bridge about two miles farther up stream; and finally, from a well-exposed section in the canyon of Rock creek. Partly interbedded with, but for the most part overlying the sandstones and shales, are thick, basaltic and andesitic lava flows, tuffs and agglomerates which have shared the dislocations to which the sediments have been subjected. Numerous dykes and laccolithic masses of varied porphyrites cut both sediments and lavas. The exact age of these rocks cannot be stated until the fossil collections are determined.

Several intrusive stocks, batholiths and many dykes of diorite, gabbro, granite and of an interesting syenite of alkaline character, cut the formations older than the Tertiaries, although, on account of their unsqueezed condition, it is believed that, in general, these eruptives are of later date than the fossiliferous beds and overlying lavas. Rather liberal collections were made from this great array of intrusive and extrusive igneous rocks; the microscopic study of these during the coming winter will form a valuable aid in the next detailed study of the belt.

Excepting the auriferous gravels of Rock creek, which have been worked in a desultory fashion for forty years (now almost entirely by a few resident Chinamen), there is no mineral deposit proved to be of economic importance in the belt. Indications of copper in the form of the common sulphides, occur in narrow quartz veins occupying zones of fracturing in mineralized quartzite on the Kettle valley slopes two miles north-west of Midway, but they do not appear to warrant development. Other narrow quartz veins containing the tellurides of gold and silver (calaverite and hessite) are reported from the diorite found on the northern end of Osoyoos lake, west side. East of that lake, a three-feet vein of pegmatite, bearing cassiterite, has likewise been reported by a prospector as cutting the coarse granite. No opportunity was afforded for visiting these localities during the reconnaissance. Minerals.

Seams of lignitic coal are embedded in the sandstones and shales of the Rock creek Tertiary, but none of them yet discovered is thick enough on the surface outcroppings to be worth exploitation.

Main division of field-work.

The larger part of the field season, from July 1 to October 15, was devoted to more detailed study of a second belt adjacent to the boundary line. The belt measures 10 miles in width and 51 in length, extending from Cascade City on the Kettle river to a point 5 miles east of the Salmon river and near the watershed between the Columbia and Kootenay rivers. Part of the area is covered by the one-inch-to-one-mile Trail map-sheet, already issued by the Geological Survey. In that section of the belt, attention was chiefly given to the delimitation of the formations found just north of the boundary but not differentiated on the preliminary edition of the Trail sheet, the only edition yet issued. Since the Rossland camp, on account of its importance, needs special investigation at once by a party spending at least two seasons in the camp, little time was this year taken in the field study of the district immediately surrounding the city.

Topography in the Gold Ranges.

The whole 50-mile belt lies in that irregular zone of the Cordilleran mountain system generalized by Dawson under the name of the Gold Ranges. The relief is stronger than in the park-country, in which the party spent the earlier part of the summer. The summits here reach altitudes of over 7,000 feet and overlook the Columbia river at 1,400 feet above sea-level. These mountains, however, rarely assume an alpine form, but usually present the appearance of rounded, forest-covered ridges and domes characteristic of the southern part of the Gold Ranges. The greater abundance of rock-exposures both in the river canyons and on the summits makes geological study less difficult than in the 'Interior Plateau,' but this feature is offset to some extent by the thick forest which impedes the progress of the explorer to a marked degree in all parts of the belt except on the highest summits.

Crystalline rocks.

The terranes encountered are for the most part highly crystalline, partly crystalline schists, partly igneous formations. Until microscopic examination of the collections from the different rock-members is made, no account of essential value can be given of conclusions derived from the field observations made on these rocks. Some idea of the great variety in the igneous formations may be gathered from the fact stated verbally by Mr. Ferrier, formerly official petrographer to the Geological Survey, that, within a radius of only 5 miles from Rossland, 108 rock-types have already been discovered. All of the formations except the later dykes and intrusive stocks have been intensely folded and faulted and subsequently so deeply eroded as to give little immediate evidence as to the geological history of the region.

About one-third of the belt is underlain by metamorphic rocks. At its extreme western end, a small patch of foliated, coarse, biotite gne-

isses, cut by pegmatite veins and by dykes of peridotite, represents an Archæan (?) band entering the belt from beyond Christina lake and the Kettle river. A much more extensive, thoroughly crystalline series of crumpled schistose rocks occupies most of the belt between its eastern limit and the Salmon river. This series includes quartzites, phyllitic, chloritic and sericitic schists, biotite schists, thick pods of crystalline limestone, amphibolites, etc. Much of this series has been referred by the first reconnaissance of the Geological Survey, to the Selkirk series. It seems to be unfossiliferous throughout and offers the characteristic difficulties in unravelling structure and plotting boundaries that every worker finds in the Gold ranges. Lying geographically between the first two series is a third, exposed best in the phyllites, quartzites, slates and marbles of the Pend d'Oreille canyon. Indirect evidence suggests a Carboniferous age for this third group of metamorphic rocks.

Fossils.

Upon these complexly folded schists, the extensive volcanic deposits associated with the ore-deposits of Rossland, were laid down. Basaltic, andesitic and more acid lavas, flows, tuffs and agglomerates, cover at the present time a second third of the belt. Erosion has not only swept away much of the thick volcanic veneer from its basement of crystalline schists, but has brought to light several large stocks of granites and syenites intruded into the volcanics since the latter were erupted, folded and faulted. Abundant but obscure remains of endogenous plants of late Mesozoic or Tertiary habit were found in certain slaty ash-beds occurring at the crossing of Little Sheep creek by the Boundary line. These fossils, when determined, should throw light on the age of the older volcanics of the Rossland series.

Rocks probably of Tertiary age.

Still younger than the plant-bearing beds and the overlying volcanics, is a fifth series unconformably related to them. It is not important either economically or with respect to the area covered, but has interest on account of the light it throws on the geological history of the region. It consists of various patches of probably contemporaneous, unfossiliferous sediments lying on the older agglomerates and on the phyllitic (Carboniferous?) formation. The rocks composing these patches are coarse conglomerates and sandstones, sometimes accompanied with tuffs and lava flows of basic composition. The patches are believed to be of Tertiary age, remnants of what is, for the most part, regarded as an irregular, necessarily more or less interrupted, group of river-gravels strongly cemented since being deposited.

Numberless dykes belonging to several different epochs of intrusion, cut these five formations and the stocks and batholithic masses which.

10

for convenience in a preliminary statement of the work done last season, have been roughly and with extreme brevity, here distinguished.

The mechanism of igneous intrusion.

Among the more pressing problems belonging to the general geology of the belt is that one referring to the method or methods according to which the intrusion of the granites and syenites of the great intrusive bodies took place. It became clear to me from a study of the facts observed in the field, that none of the existing theories of intrusion adequately explains the conditions characterisitic of these stocks and batholithic bodies. The origin of the subterranean chambers once occupied by those bodies, and the process by which the invaded formations were so far displaced by the irruptives, form different phases of the same problem; their discussion has to do also with the origin of the abundant igneous rocks of the belt. It has been considered advisable to present in a generalized form, the hypothesis derived from the field-studies of the past two seasons in the Boundary as well as from earlier investigations of eruptive areas, rather than to note specially in this report the concrete phenomena observed during the season just closed. (The statement of the hypothesis will be given in two papers appearing in the American Journal of Science.)

Glaciation.

The glaciation of the belt led to more severe erosion and more complete removal of rock-débris than in the region west of Midway. The drift is consequently less abundant and the rock-exposures more numerous. The upper limit of glaciation was definitely fixed on Record Mountain ridge west of Rossland and elsewhere in the belt, as very close to 6,400 feet above the sea. The south-flowing Cordilleran glacier was, at its maximum, 5,000 feet thick over the axis of the Columbia River valley. Many horns and ridges at that time, projected above the ice as 'nunataks.' Above the 6,400-feet contour, the summits are covered with felsenmeers or mantles of often deeply decayed angular rock-fragments slowly streaming down the slopes. The relatively few ledges there exposed are ragged, greatly weathered and, like the felsenmeers, bear no drift. The contrast with the glaciated slopes below is always sharp and striking.

Mineral deposits.

Since the main purpose of the survey along the Boundary is that special one of developing as far as practicable a detailed structural section across the whole Cordillera, not much time could be devoted to the different, though connected, problems of the mining geology of the belt. Many claims and a few working mines were, however, visited, and data collected which will be used in the preparation of the final report on the Boundary. Of particular interest was an extensive deposit of hematite, largely limonitized, occurring in the marbles on

the north side of Boundary creek about one-half mile up stream from its confluence with the Pend D'Oreille. The ore-body has been traced on the outcrop for a distance of a mile and a half. It is of variable thickness, but the degree of the variation could not be fully determined because of the lack of time and of natural exposures at many points desired. A tunnel has been driven forty feet into the solid ore where it crosses Boundary creek but much development work will be necessary beneath the deep wash before an accurate account of the prospect can be given. A few grains of pyrite were seen in ore-fragments taken from the dump at the tunnel; failing the required assays as yet, it is impossible to be certain how far the ore is injured by the sulphide. Partial assays reported by Mr. Feeny, one of the co-owners of the property, showed 59 to 61 per cent of iron in the ore, which is thus of high grade quality. The apparent strength of the ore-body, the proximity of abundant flux material, of wood for charcoal furnaces, and the easy access to the property from the Nelson and Fort Shepard Railway, render the deposit worthy of special attention. It is highly probable that other similar deposits will be found on further prospecting in the vicinity. Marbles of economic value may also be expected to occur as phases of the thick masses of crystalline limestone lying between the Pend D'Oreille river and the Salmon river.

The general rock-types and structures characteristic of the Rossland camp are known to be represented in other parts of the igneous formations to which they belong, and smaller ore-bodies similar to those at the camp have been discovered at points distant from the city. It is therefore possible that other copper-gold ore bodies of importance comparable to that held by the deposits of the famous camp will be found elsewhere in the volcanic series. Quite different, low grade gold, silver, and copper deposits in quartz-veins have been staked out in the schistose formations lying east of the Salmon river. So far, the tonnage of ore-bearing quartz exposed at any one of these claims is so small as to forbid active development. Many quartz-veins in the schists and quartzites forming the rough sierra between the Salmon and the Kootenay, run from 25 to 150 feet in width. Thorough prospecting among these, checked by numerous assays, may yet reveal precious metal deposits of great value, though they must be expected to show only low-grade ore. The most favourable outlook will be for free-milling gold-quartz.

Auriferous gravels.

The auriferous gravels in the abandoned former channel of the Pend D'Oreille river were among the first deposits to draw the attention of the mining world to the province of British Columbia. The gravels at Boundary Town seem now to be practically worked out and no min-

ing has gone on for many years at this camp. Placering and 'sniping' on a small scale are carried on by the few ranchers occupying the Pend D'Oreille valley. More extensive hydraulic works were in process of construction this summer at the mouth of Fifteen Mile creek, and are intended to handle the terrace-gravels largely derived from the bed of that torrential branch of the river. The cubic contents of all the gravels on the Pend D'Oreille between Boundary Town and the crossing of the International boundary eighteen miles up the river, is, however, small, and it is improbable that hydraulicing on the scale, for example, of the 'wild cat' plant (costing, it is said, more than a quarter of a million dollars) on Seven Mile creek, can be made to pay anywhere along the river within the points mentioned. Small, easily worked monitors may be installed here and there and find pay gravels sufficient for their needs during a few seasons, as there is abundant evidence of the gold-bearing nature of the Pend D'Oreille gravels wher ever they occur on the Canadian side of the line. It must be remem bered that the gravels are poor in the precious metal at all points yet prospected in the valley except at Boundary Town; hydraulicing should not be permitted in certain parts of the valley bench-land now cleared and shown to possess fair to good soil for farming and fruit-growing. The Salmon river gravels are also auriferous but of small volume. Throughout the whole interrupted line of the deposits from the Columbia to the forks of the Salmon, the gold is generally rather fine, though coarser metal is found in 'sniping'. The chief source of the gold is doubtless to be sought in the innumerable small quartz veins cutting the volcanics and schists on the north side of the Pend D'Oreille, and cutting the schists to right and left of Lost creek and other branches of the Salmon.

During the season the following observations for magnetic variation, were made. All readings were taken from the axial lines (marked by monument flags) of the slashes cut on the 49th parallel. The instrument used was a 'Brunton Pocket Transit' provided with a needle measuring two and a half inches, and an effective distance of about five inches between peep-hole and vertical thread.

Magnetic variation.

Each of the following values forms the average of several readings at the locality noted:

	°	'	
Midway	22	30,	east.
Five miles west of Midway	57	00*	"
Fifteen miles (about) west of Midway	24	00	"
Nineteen " "	36	00*	"
About five miles east of Okanagan Lake	23	00	"

* Special local attraction.

	°	′
Okanagan lake	23	45 east.
Cascade City, Kettle river valley	22	50 "
One mile east of Cascade City	22	15 "
Five miles " "	22	10 "
Top, Sophie mountain	23	00 "
West slope, Sophie Mountain.	23	45 "
Little Sheep creek valley	24	00 "
Columbia river, Boundary Town	22	50 "
Summit, five miles east of Pend d'Oreille river	23	00 "
South Fork, Salmon river	22	45 "

Notes on the Geology of Anthracite, Alberta.

Mr. H. S. Poole.

A visit was paid in November to the coal fields of Anthracite on the Bow river, where the Canadian Pacific railway enters the Rocky mountains. Through the courtesy of Mr. O. E. S. Whiteside, B. Sc., the superintendent of the mines, an opportunity was afforded me of going underground, and also of seeing the carefully kept plans of the workings.

General structure already described.

So far as the general structure of the field is concerned (further than the discovery of additional seams in the series) but little more information has been acquired from surface exploration than was known when the Geological Survey Report for 1885, B. 1261, was issued, but the mining operations have exposed a series of foldings of the coal-bearing beds throughout the valley of some complexity.

Cretaceous coal measures.

In much of the Cretaceous rocks occupied by the valley of the Bow river in this locality, the river has at some time or other taken its course, and by its shifting channel cut the coal-bearing series down to the general level of its present bed. At a later date the valley has been filled with well-worn gravel, in some places to a depth of as much as 200 feet; and this deposit the river is now engaged in removing, but still leaving broad terraces which in some spots no doubt cover over and hide from view outcroppings of the coal strata. It is doubtful if the river has got down to the level it occupied before the deposition of the terrace gravels, and until this has been determined additional caution has to be exercised when mining coal on the uprises of the secondary folds below the stream, lest connection be unexpectedly made with the water-soaked gravels of an ancient channel. The slope on 'A' seam has been carried down 684 feet.

Caution urged in mining.

The coal seams crop on the northern side of the valley, with a varying degree of inclination to the southward, but so far a continuity

Connection with coal of Canmore not proved.

of the seams of anthracite with those of bituminous coal at Canmore, ten miles distant, has not been traced, and no natural exposures are known in the intervening ground. To the northward, on the Cascade river where the same series is exposed, explorations have been made and prospectors report finding the quality of the coal change from anthracite to bituminous within a remarkably short distance. On the south side of the valley there is also a lack of natural exposures and heavy deposits of gravel interfere with the development of the structure to the deep of the workings along the crop. Underground operations have sufficiently exploited the field to show that the strata have been thrown into folds, having a course somewhat diagonal to the general line of strike, N.W. and S.E., and more to the southward. The chief folds incline and broaden in that direction, but their determination has not been made out. It may be suggested, however, that cross faults, with downthrows to the S.E., carry them to the north-east, near the junction of the Bow and Cascade rivers. The workings at Anthracite proved one such main fold, with a southerly dip varying from 20° to 50°, and with the axis of the trough directed to the south-east and turned up rapidly to the vertical, or in places overhanging on the south side. This south side has been followed upwards for 300 feet, but the structure still further southward has not yet been proved. Further down the valley, a lateral displacement of over 2,000 feet is presumed to have occurred, and while the orogenetic movements have not, at Canmore, eliminated much of the volatile matter of the coal, they have greatly altered the associated measures.

Folds of strata.

Faults.

Mr. Whiteside does not consider he has yet obtained sufficient data to satisfactorily describe and illustrate this field, but from operations now in progress at Canmore, he hopes shortly to be enabled to do this.

Sections given by Mr. Whiteside.

The following are revised sections of the coal seams of the Anthracite series, in descending order:

	Ft.	In.	Ft.	In.
'B' seam:—Mining	1	0		
Slate	0	7		
Coal after slating	4	4		
Slate	0	0½		
Mining	0	5½		
			6	5
Measures			125	0
'A' seam:—Mining	0	3		
Coal	1	0		
Slate	0	1½		
Coal	4	9½		
Mining	0	2		
			6	4
Measures			110	0

No. 1 seam :—Bone and dirt	1	3		
Coal	2	0		
Slate	0	2		
Coal	0	5		
Slate	0	2		
Mining	1	2		
Slate	0	1		
Coal	0	5		
Slate	0	4		
Coal	1	2		
Mining	0	2		
			7	4
Measures			90	0
No. 2 seam :—Coal	2	2 to 3 ft. 3 in.		
Slate	0	4		
Mining	0	6		
			3	0
Measures			86	0
Mining	0	10		
Coal	1	2		
Slate	1	6		
Coal	1	8		
			5	2

The Region South-west of Fort Smith, Slave River, N.W.T.

Mr. Charles Camsell.

Area included in report.

The following report is based on work which was carried out during the season of 1902, in the country to the south-west of Fort Smith, in the angle between the Peace river and the Great Slave river.

On receiving my instructions from Dr. Bell, I left Winnipeg on June 3 for Edmonton, where I spent a few days in obtaining supplies and making other arrangements for my trip. Here I also hired Duncan Mackay as canoeman, and he was my sole companion for the greater part of the summer. The trip to Athabasca landing took much more time than is usual, owing to the fact that nearly all the bridges had been washed away by the unusually high water, and our canoe which we were also transporting was very useful in ferrying supplies across the streams.

We reached Athabasca landing on the 16th and left next morning for Fort Smith in our canoe. The rapids on the Athabasca river were run without any mishap, and we arrived at Fort Smith on July 1.

Track survey of Salt river.

A canoe trip up the Salt river being part of the programme laid down in my instructions, I decided to make this at once before the water

got too low for navigation, and, even at this date I was informed by the residents of Fort Smith that I would not get far up. However, we left Fort Smith on July 3, and spent a week in making a track-survey of Salt river, as well as an examination of the country on both sides of the stream. Mr. McConnell in the summer of 1887 ascended Salt river as far as the brine springs, and his account appears in the reports for that year. We were only able to get about 20 miles higher up than Mr. McConnell, when the stream became too shallow and too much choked with trees, for canoe navigation.

Salt springs.

The Salt river enters the Slave river about 18 miles below Fort Smith, and is about 40 yards wide at its mouth. At the time we passed up, it had little or no current for some distance. The water is quite fit for drinking for about three miles up, but above this it becomes more and more salty until we get to the brine springs at the forks of the river. Above this, the amount of salt held in solution decreases in quantity, but the water is still unfit to drink. Its general direction is about south (magnetic) as far as the forks at 20 miles from the mouth; then it turns sharply to the east and was still flowing from this direction when we turned back.

Five miles up from the mouth, the banks of the stream suddenly rise from five feet to thirty feet and are of alluvial origin; beyond this point the height gradually decreases to the springs, where it is only about six feet, but on going higher up stream and away from the Salt plain, the banks soon reach their former height of thirty feet. This would show that the Salt plain, which rnns parallel with a steep escarpment to the west of the river, lies in a depression that is greatest just along the base of this escarpment.

Steep escarpment.

The escarpment itself is about 210 feet high, with a rather steep slope, generally well wooded with poplar and spruce, but showing here and there outcropping strata of limestone, and running in a general direction about north-west and south-east. We entered the Salt plain about ten miles above the mouth of the river; though from the river one does not notice it, as the banks are everywhere thickly wooded by a belt of timber 100 to 200 yards in width. The greatest breadth of the Salt plain does not exceed eight miles from north-east to south-west and its least breadth is about two miles. Its length could not be determined accurately; but I know that it is at least fifteen miles. It is by no means an unbroken stretch of prairie land, but is interspersed at short intervals with clumps and groves of poplar and spruce; and on going northward the wooded areas gradually increase until forest predominates over prairie. In the neighbourhood of the brine

springs the ground is barren of vegetation and numerous small saline lakes and ponds appear here and there. On other parts of the prairie, grass grows in abundance, affording splendid feed for cattle and horses, and indeed the latter animals are never housed, but roam over the prairie all winter and are in splendid condition by the spring.

Trips were made into the interior in several places on both sides of the river and particularly on the west side to examine the nature and occurrence of the sink-holes which appear on the sides and top of the escarpment. A description of these will be given further on. Sink-holes investigated.

The brine springs, which occur near the forks of the river and from which the Hudson's Bay Co. gets its supply of salt, were located and an observation for latitude taken to determine their position more accurately. Other brine springs were also discovered about six miles south-east of the forks. A much larger accumulation of salt occurs here, but on account of their being some distance from navigable waters, the salt from these springs has never been utilized. All these springs are situated along the base of the escarpment and at the time of our visit were nearly dry. They generally rise from among an accumulation of granite boulders and flow thence into shallow basins, where the water is evaporated, leaving a deposit of coarse salt. The stumps of trees, the boulders and the ground in the neighbourhood of the springs are all incrusted with the salt.

Fish are plentiful in the waters of Salt river, and the brine springs are a resort for moose and bear, which come there to lick the salt. A skull of a wood buffalo was also seen here, showing that these animals also frequented the neighbourhood, though none have been seen in the neighbourhood for some years. Fish and game plentiful.

We returned to Fort Smith on July 9, and immediately set about making preparations for a trip overland with horses. It was the original intention to make this overland trip with a wagon or cart, but I found that it would be useless to attempt it, as the only place where a cart could be used would be on the Salt plain and many miles of bush road would have to be cut to get there, and beyond that a trail would again have to be cut. So I abandoned the idea and took pack-horses instead, at the same time hiring another man to act as guide.

We again left Fort Smith on July 12, this time with pack horses, taking provisions for two weeks as well as an extra supply to leave in a cache on Little Buffalo river, for I contemplated a canoe trip up that stream later in the season.

Timber and hay.

For the first 10 miles after leaving Fort Smith the trail runs in a general direction S. 25 W. magnetic, through a level or slightly rolling country, well wooded with poplar, spruce and Banksian pine, with occasional swamps in which large quantities of hay could be cut. Then the forest gradually shades off into open fertile prairie, which extends up to Salt river, the river itself being fringed with a dense growth of poplars and willows. The crossing of Salt river is made just below the second large branch of the stream, and is rather a risky undertaking, as the bed of the river consists of a soft tenacious clay which would easily mire a heavily laden pack-horse. We camped the first night out from Fort Smith at this crossing, getting our drinking water from a small pond on the south side of the river.

Our course from the crossing was S. 20° W. (mag.) leading straight towards a bay in the escarpment to the west. After passing through the belt of timber along the river bank, we again emerged into the prairie country which extends up to the base of the escarpment. This part of the prairie is not nearly so fertile as that east of the river, and although it is largely covered with grass, there are a number of white barren alkaline patches which increase in size as the escarpment is approached. The first branch of the Salt river is forded three miles from the crossing of the main stream. It is only about twelve feet wide, and one foot deep with a gravel and clay bottom, and the water is very salty to the taste. A number of rounded wooded hills, 20 to 60 feet high, were noticed near this place standing like islands on the prairie and generally surrounded on all sides by barren patches. These hills were probably at one time connected with the escarpment to the west, but being composed of harder strata than the rest have resisted the action of erosion which caused the escarpment to retreat to its present line, leaving them as residuals to mark the line at which the face of the escarpment once stood. Scattered here and there around the base of these hills are boulders of granite and other igneous rocks. An exposure of much weathered limestone was crossed on the prairie about two miles from the escarpment. As the base of this is approached the barren patches give place to small saline lakes and ponds, the neighbourhood of which is very boggy and marshy.

Hills marking ancient face of escarpment.

The trail mounts the escarpment to the right of a small fresh water creek which enters the Salt plain through a narrow wooded valley and joins the first branch of the Salt river. From the top of the escarpment the trail runs three miles and a half through a very broken hilly country, timbered with poplar and Banksian pine; the roughness being due to numerous large deep sink-holes. The deepest of these would be about 50 feet. No exposures of rock were seen on their

Sink-holes.

sides which were all covered with a considerable depth of light-coloured sandy waste. Just beyond these we entered an area of burnt rolling country which extends for 3 miles along the trail. This area had been burnt probably 25 years ago and is now covered with a thick growth of young Banksian pines.

Leaving this burnt area, a short steep descent is made in low swampy land with several muskegs. It is only in these muskegs that any deep moss is seen, the greater part of the country being dry with little or no covering of moss.

Gradually again going south-westward, the country becomes more open and dry until after about four miles we get into what the natives call prairie, but it is really only a succession of small prairie openings, few of which are more than 150 yards long. We travelled through this for about five miles and seemed to be going diagonally across it. The prairie itself runs nearly north and south. It is said to continue with frequent interruptions nearly as far down as Great Slave lake, running parallel with the Little Buffalo river and on both sides of it. It is in this open country that the wood buffalo are to be found. Wood buffalo. While making a camp on the shore of Flat Grass lake we disturbed a small band of ten or twelve of these animals, but we were unfortunate in not getting a sight of them. Although they are protected by law they do not seem to be increasing as fast as they should. The Indians are very careful now that none should be killed by hunters; but are not so particular in protecting them from the timber wolves, which are the cause of the lack of increase. A full-grown animal can easily take care of itself, but the young buffaloes fall an easy prey to wolves. If some inducement were offered the natives for the killing of timber wolves there would be a greater increase in the number of buffaloes.

Flat Grass lake lies about half-way across the so-called prairie and is a shallow marshy lake a mile and a half long by half a mile wide. The shores are covered for fifty or sixty yards with thick grass. Ducks were plentiful in the lake. Many ripe strawberries were seen on its shores.

Four miles and a half from Flat Grass lake the trail strikes Little Little Buffalo river. Buffalo river, which is here about 25 feet wide with a good current, and many large boulders in its bed, which form small rapids at various points. The trail follows the east bank for another five miles through a thickly wooded country, the greater part of which had been burnt, probably twenty years ago. A crossing is then made to the west side of the river at a point where the water is only about eight

inches deep and very rapid. For about twelve miles the trail then follows the west bank of the stream, touching it here and there, but frequently being a mile or more away from it.

Here also the country had nearly all been burnt at the same time as that on the east side. The trail on the west side is seldom used in summer and runs through a very swampy country, occasionally rising on to narrow sandy ridges, wooded with poplar and Banksian pine. Some distance ahead could be seen a low range of hills running nearly true north and south and where the Little Buffalo river cuts through these, a second crossing is made back to the east, or locally the south side. These hills are known to the Indians by the name of Nini-Shith, or fallen tree hills; so called on account of the great number of fallen trees upon them. Their highest points do not exceed 150 feet, and where the river cuts through them, they are seen to consist entirely of sand. To the sonth-east they could be seen stretching away for eight or ten miles in a series of high rounded hills connected with each other by lower ridges. To the north-west all the ridges seem to be merged into one, much broader than the rest.

On the east side of the river we were still in burnt country and I may say, that this area extends for a distance of 25 or 30 miles from north-east to south-west and runs as far to the north-west and south-east as could be seen from the top of the hills.

About six miles beyond the second crossing of the river, we ascended a ridge, 100 feet high and followed this in a south-easterly direction for nearly three miles. The ridge is very steep and narrow, resembling a moraine, but it is composed entirely of sand. From its highest point a good view of the country was had. To the south-west, Cariboo mountain could be seen on the horizon, looking blue in the distance, and about five miles away stretched another ridge almost parallel to the one we were on and hiding the view between that and Cariboo mountain. To the north-west could be seen the shallow valley of the Little Buffalo and to the east, five or six miles away, another ridge parallel to this one and higher in a good many places. Between the two ridges lay a large muskeg, mostly dry, but here and there showing small gleaming patches of water. Judging by the shells on the muskeg, the whole must have been covered with water at no very remote period.

Cariboo mountain.

Since crossing the Little Buffalo river the last time, we had been following no trail at all, but on the top of the ridge, we found an old buffalo trail, and had fairly good going to the end of the ridge. Old buffalo wallows were also numerous on its top.

Leaving this we descended to a muskeg, where we had great difficulty with the horses on account of the boggy nature of the ground. In several places the moss is dry and thick, and a fine black powdery dust rises behind the moving animals. The muskeg is treeless, except for a few small stunted spruces.

On crossing the muskeg the land begins to rise almost imperceptibly up to a height of 80 feet, and on the northern slope of the hill there is as fine a growth of spruce and poplar as I have seen north of the Peace river. Spruce trees 26 inches in diameter and poplars 18 to 20 inches are common. There is no underbrush, and the ground is covered with about four inches of soft moss, the whole having a park-like appearance. On the top of the hill the timber becomes much smaller and the growth thicker, so that we had some difficulty in forcing a way through. Fine spruce and poplar.

Three miles beyond this last ridge we crossed another, but not before making a great detour to avoid Brabant lake, which is about two miles long by half a mile wide, and without any outlet. Descending into the next valley, we passed Loon lake on the west side and about a mile beyond it reached the shore of a large lake called by the Indians Moose lake. This is a beautiful sheet of water about eight miles long from east to west, and about four miles wide. A small creek flows from the west end into the Little Buffalo river, but it is not navigable and the Indians usually carry their canoes across a portage to get into the lake.

I had hoped to be able to reach the Cariboo mountain, but I now saw that it would be impossible to do so with horses, as there is no trail, and the country is practically a huge muskeg up to the base of the mountain. So after sketching in the shores of Moose lake I was reluctantly compelled to return to Fort Smith, arriving there on July 22, after having been away 11 days. At Fort Smith I gathered as much information as possible about the canoe route from hence to the Peace river, via the Little Buffalo and Jackfish rivers. Very few of the Indians had ever been over it, and then only during high water in the spring, and these doubted whether it could be followed at this season of the year, and advised me to go in a small birch-bark hunting canoe. To hire a guide for the whole trip was impossible for several reasons, one of which was that an epidemic of sickness had visited Fort Smith and nearly every able-bodied Indian was laid up; so I had to content myself with a rough sketch of the route, supplemented by a good deal of inaccurate information. On the 2nd of August I started again with Mackay, for the last time from Fort Smith. Return to Fort Smith.

Going down to the mouth of the Salt river, we camped there and succeeded in inducing an old Indian to go with us as far up the Little Buffalo river as the point at which the summer trail first strikes it. Although he was a man about 60 years of age and could not do much work, his knowledge of the route saved us a good deal of time, particularly in finding the portage.

Ascend Little Buffalo river.

Leaving the mouth of Salt river we again ascended that stream for twelve miles before coming to the trail leading to the Little Buffalo river. A short portage of some 30 yards is first made into a little pond about 100 yards long, and from it the trail mounts a small rise of twenty feet and enters a fine country sparely wooded with poplar and green alder. This kind of country continues for half a mile, when the trail runs into an open prairie, stretching nearly to the Little Buffalo river. This is part of the Salt plain, and like the other parts, is broken here and there by strips of timber. The total length of the portage is nearly seven miles and its general direction S. 70° W. (mag.) About a mile to the south of the portage trail is a continuation of the escapment mentioned before, which here runs parallel with the trail; but after crossing the Little Buffalo river it bends more to the north and seems to decrease slightly in height. Exposures of limestone can be seen in several places along its face. Along its base are a number of small saline lakes and here and there barren alkaline patches occur. As a rule, however, the prairie is covered with a luxuriant growth of tall grass. The great difficulty in traversing the portage is the scarcity of drinking water, and the only place where this could be obtained was a small pond three-quarters of a mile north of our camp of Aug. 4. From this point to near the Little Buffalo river, water had to be carried, as that of the Lop-stick creek itself is not fit to drink. In a season of greater rainfall, however, there would not be the same difficulty. For the last three miles the trail runs through very wet and boggy country, but the water in the numerous ponds is always more or less saline.

Drinking water scarce.

Lop-stick creek.

The portage ends in Lop-stick creek, which is not more than 10 feet wide and exceedingly crooked. It is so called because of a tall lop-stick, standing on its bank, which marks the point at which the trail strikes the creek, and which can be seen for a distance of two miles.

Like the Salt river, Lop-stick creek is fed from springs along the base of the escarpment and the water is consequently salty in taste and has a bluish colour, while the bed of the creek is covered with a thick green moss. To the south the course of the stream can be traced by a line of spruces and willows, and it empties into the Little

Buffalo river about two miles north-west of the portage. At the time we went through, the creek as well as the ponds on either side were teeming with ducks.

At the junction of the Lop-stick creek with the Little Buffalo river, the latter is about 60 feet wide with little or no current. The water is deep but not clear. The banks, about four feet high, are well wooded with spruce and willow, with a good deal of swamp grass near the water. The Little Buffalo river empties into Great Slave lake a few miles west of Fort Resolution, and is frequently used in the early spring as a canoe-route from Fort Resolution to Fort Smith, as it breaks up earlier than the Slave river. It has been explored as far up as the Salt river portage, but hitherto no explorer has been beyond this point. We were soon made aware of this fact by finding at short intervals huge trees lying across from one bank to the other, all of which had to be cut out to permit a passage for the canoe. The water of the river is not very good to drink, but still it is much better than that of the Lop-stick creek. Description of Little Buffalo river

The course of the river above the Lop-stick creek is slightly east of south up to the base of the escarpment, when it bends more to the west, and it is exceedingly crooked. Exposures of limestone are first seen where the river emerges from the higher land, and here also is a cliff of impure gypsum ten feet high at the base of the escarpment. The height of the banks soon increases to sixty or seventy feet and the current becomes much swifter. Short shallow rapids are formed here and there, either by accumulations of boulders or as a result of the work of beavers.

For six and a half miles above the first exposure of limestone, or as far up as the falls, the valley of the river much resembles a gorge. It averages about 150 yards in width and is altogether out of proportion to the size and volume of the stream, which is only about forty feet wide. The sides are nearly vertical walls of horizontal limestone from seventy to 100 feet in height; and in places where I climbed to the top of these cliffs, I found that the country above and behind them was much cut up with deep sink-holes, in some of which the solid rock was exposed, but as in the case of those seen earlier in the season, the majority of them were lined with debris. The timber here consisted largely of poplar, and in the valley I noticed balsam fir for the first time. Gooseberries, raspberries and saskatoons were seen in great abundance. Valley resembles a gorge.

Half a mile below the falls the river becomes too shallow and rapid for canoe navigation, and here a portage of three-quarters of a mile is

made on the east bank. The trail runs through a broken hilly country wooded entirely with poplars and willows; and the difference in elevation between the north and south end is nearly 100 feet. The river itself makes a bend from the lower end of the portage, first to the south-west and then to the east, and about half-way round this bend are the falls, while above and below for some distance are a series of shallow rapids, the lower ones filled with sharp angular boulders of limestone, and the upper with rounded boulders of igneous rocks. There are three separate falls, the lower one being much the greatest. In this one there is a sheer drop of forty feet over the limestone, the upper stratum of which is harder and more resistant than the lower, and consequently the upper overhangs slightly, so that it is possible to walk across the river between the falling water and the cliff, but not without getting wet from the spray. The volume of water falling over was small and its width only about twenty-five feet. There is a deep basin at the foot of the falls almost completely surrounded by vertical walls of limestone 100 feet in height. The middle fall is 100 yards above the lowest and has a drop of about sixteen feet in nearly twice the horizontal distance. It is a more beautiful sight than the other, as it has the form of a crescent and the water falls over thin beds of limestone in a series of short steps. The upper fall is about seventy-five yards above the middle one and has a drop of only five feet. Above this there are shallow rapids as far as the end of the portage. The gorge below the falls measures the distance those falls have receded from the face of the escarpment since the genesis of this part of the river, and shows it to be about six and a half miles. Samples of the limestone and some fossils were collected from this place.

Falls.

Soon after leaving the falls the course of the river turns towards the west and continues in this direction for three miles, when it again bends gradually towards the south, and twelve miles farthur on, towards the south-east. There is little of interest to distinguish one part of the river from another and as far up as the summer trail there is merely a succession of shallow rapids, dead water and log jams. A few short portages were made to avoid log jams, the longest of these being 300 yards. Beaver dams were also very numerous, but only the larger new ones were noted. The width of the stream above the falls averages about thirty feet and the banks are usually about four feet high, fringed with grass. The prevailing forest tree is spruce, but tall willows frequently form an archway over the stream.

Beaver dams.

Four miles south of our camp of August 8, we entered an area of country which had been burnt about twenty years ago. This extends

on both sides of the river, for about ten miles, and it is here that many of the log jams occur.

A winter trail from Fort Smith to Bog lake crosses the river about seven miles north-west of the summer trail, and this trail also crosses the Salt river at the forks. It was near this winter trail that on August 11 our old guide turned back, and from here on, we had to find our way merely by the aid of a rough map that he made for us.

From the summer trail up to the Nini-shith hills the course of the river is about S. 30° W. magnetic, and it varies little in general character. The valley is generally half a mile wide and only about 25 feet deep, while the adjoining country on either side is a thickly forested, level or gently rolling plain. The only creek of any size entering in this stretch is Sucker creek, flowing in from the east about three miles above the first crossing. It is about thirty feet wide at the junction, but with no current and very little depth of water. Beaver dams are numerous, and shallow rapids are met at nearly every turn and in one of these the bed was seen to be composed of limestone. The country on both sides has here also been burnt, but no log jams occur, as the river is almost entirely fringed with tall willows. Sucker creek.

After passing through the Nini-shith hills, the course of the river is nearly west for about six miles, where at the entrance of a small creek from the north it turns sharply to the south again. There is a strong current all the way, but no rapids occur. The bed of the river is covered with grass and has no boulders. It is probable that the boulders in the river below the Nini-shith hills come from these hills, but in the cut banks none could be seen Areas of good hay are frequent in the valley of the river, which is from 200 yards to a quarter of a mile wide, and in a few places that had been untouched by fire, spruce trees, up to twenty inches in diameter can be seen, but there is no birch or balsam.

At our camp of August 13 the valley of the river is much narrower and the course of the stream is south, gradually bending to the south-east as it approaches a high wooded ridge running east and west. Where the river meets the ridge, cut sand banks 25 and 30 feet high are seen. About half-way down the last stretch, a small creek enters from the west, and on following it up for about 300 yards, I found that it was highly sulphuretted, and that a strong odour of hydrogen sulphide was given off when the moss in the bed of the creek was disturbed. The creek rises in a small pond 40 yards across, and although the water is beautifully clear and the bottom everywhere Sulphur spring.

visible, I could not locate the exact position of the spring which is the source of supply. The taste of the water was distinctly sulphurous and the moss and stumps in the bed of the creek were covered with a white coating.

In its course through the ridge mentioned above, the river becomes very shallow and rapid, and sharp angular boulders of limestone are frequently seen, but no rock in situ. In these rapids on account of the difficulty of cutting out portages, we found it quicker to remove the boulders from the channel and make passages for the canoe. It took us the greater part of a day to get through these rapids, although they only extended for three miles.

Portage route to Moose lake. A small creek enters from the east just above these rapids, and near the mouth of the creek we found the trail over which the Indians portage their canoes to Moose lake.

Above the Moose lake trail the river widens to 50 feet and we passed a number of beaver dams; but instead of being a hindrance to us, they were a great help by raising the level of the water above them. These dams were generally about two feet high and well constructed with stones and willow brush.

After passing through another low wooded ridge, in which we again encountered a number of rapids, we entered a low swampy country where the river widens to 100 feet or more. Moose creek enters from the south, just above these rapids, and at this point the Little Buffalo river takes a sharp bend to the north-west. Followiug this course for three miles, we enter a small marshy lake half a mile long and about the same in width. We leave this lake half way down the south shore and in a little more than half a mile enter a larger lake. Both of these lakes are shallow, and the bottom of each is covered with a soft slimy mud, into which a paddle can easily be thrust three or four feet. The shores of the lakes are covered with grass and willows.

The river enters the second lake about half a mile from its outlet on the west side, and a short distance up becomes very difficult to navigate, for the willows from either bank meet in the centre and completely block the passage. The banks are about 2 feet high and are continually caving in so that the stream has to cut new channels for itself.

Bog lake. Three miles above the lake we reached the forks of the river, the left branch coming from a large lake one-third of a mile to the west. The Indians call this Thul-tue or Bog lake. Its length was estimated

to be about eight or nine miles and its greatest width lying nearly north and south. It contains plenty of fish and is a favourite winter resort for the Indians trading at Fort Smith. At one time the lake probably extended over all of the river valley as far down as the last mentioned rapids, for the whole of this part lies in a well defined valley and is still very wet and marshy and covered with swamp grass and willows, while the river is confined to its present bed only by a low narrow rise on either bank, and behind this it is very boggy and marshy and rather dangerous for walking. The deepening of the channel at these rapids, however, caused the water to drain off, lowering the lake to its present level and shore line. The water of the Thul-tue branch is very muddy, while that of the main stream is clear and amber-coloured.

Half a mile above the forks a small stream eight feet wide with a strong current enters from the south-east, and this we at first took to be the right stream to follow ; but on going up a quarter of a mile fonnd it too narrow and crooked for the canoe. I have since learned that this creek rises in a large lake to the south-east, from which a portage is made into the Jackfish river. The other stream, judging by the width of its bed, is the main stream, but on ascending it for half a mile we found it almost dry ; that is to say, where the water broke through an old beaver dam, it was only a few inches wide. According to our Indian map this was undoubtedly the right stream to follow, so on the morning of August 18, we made a long portage to avoid a succession of old beaver dams until we came to a large new dam, above which we found plenty of water and good paddling. In this part of the river, new dams are built nearly every year, each one a short distance above the one of the previous year, until for a distance of two miles and a half there is a series of dams at intervals of 50 or 100 yards.

Beaver dams frequent.

Three miles above the last new beaver dam we entered a small muskeg * lake about one mile long. North, east and west of this the country is an immense muskeg, while to the south is a low wooded ridge of poplar, spruce and Banksian pine. The muskeg as well as parts of the ridge had been burnt over years ago.

We left the lake half-way down the west side, and after going westerly for three miles, found that the stream suddenly contracts to a width of a few feet and is so blocked with willows that we were unable to force a way through for the canoe.

At this place we spent half a day searching for the portage trail to Jackfish river, and finding none decided to cut one for ourselves. The distance across is only four miles and a half, but it took us two

Cut portage trail to Jackfish river.

* Marsh.

days to make the portage. Cariboo mountain could be seen to the south and taking a course S. 10° W. magnetic, we made straight for three rounded peaks that could be seen on the top of the mountain. Our trail for the first three miles took us through burnt open muskeg, with several boulder ridges covered by poplar and pine which constitute the height of land between the Little Buffalo and Jackfish rivers. The last mile and a half lay through swamps and muskegs; and over the whole trail not a great deal of cutting had to be done except at the Jackfish river, which is fringed with a dense growth of spruces, alders and willows. We got everything over to the Jackfish river on the afternoon of August 21, and the same evening started down stream.

Where we first saw the Jackfish river it is 40 or 50 feet wide with a sluggish current and veiy muddy water. Its banks are of clay and about five feet high, fringed with grass and wooded with fine large spruces, some of which are 30 inches in diameter, and as in the Little Buffalo river, log jams are of common occurrence. The river runs parallel with the Cariboo mountain, which can be seen, eight or ten miles to the south-west, rising with a long gentle slope to a height of perhaps 1,500 to 2,000 feet above the level of the plain. The valley is very wide and shallow, occupied largely by open muskegs, and through it the river meanders in a very sinuous course. We took seven days in going down to the Peace river, though when the river is in flood it can be done in three days.

Topography.

The general course of the Jackfish river from the portage down to Jackfish lake is about south-east. It resembles the Little Buffalo river in the frequency with which shallow rapids, log jams, and beaver dams occur; the rapids here also being formed by accumulations of boulders of granite and other igneous rocks. Hay may be obtained in large quantities in the swamps near Jackfish lake.

Jackfish lake.

Jackfish lake, through which the river runs, is a narrow sheet of water measuring about four miles in length, the south end of which approaches much nearer to Cariboo mountain than any part of the river. The shores are usually grassy, but in several places gravel and boulders are seen. The outlet is about half way down the east arm on the north side, where the river is about 100 feet wide and the banks hardly rise above the water.

For fifteen miles below Jackfish lake the course of the river is slightly north of east, running through a low swampy country wooded with spruce and willow, and in which a few low mounds rise above the level of the plain. As we approached the end of this reach the

banks gradually became higher and the current much swifter, until we again got into a succession of rapids, where gravel banks were first seen. Passing through these rapids the river takes a sharp bend to the south and for the next ten miles the only obstructions to navigation are the log jams. Hills 150 feet in height rise on either side of the river, and soon after passing through these, we again entered a series of shallow rapids, none of which were bad enough to compel us to portage, but several were too shallow to run with the canoe.

We were delayed at our camp of August 23 by rain, and soon after leaving it we entered a shallow grassy expansion of the river. This in the early spring or in a season of high water would be a lake three miles long by one mile wide, but was now almost dry. A mile and a half below this we passed the mouth of Berry creek, a very muddy stream thirty feet wide which joins the Jackfish river from the west. From thence to Gravel creek, a distance of about seven miles, the current is very slack and the river frequently choked with driftwood.

Gravel creek enters from the west, but unlike Berry creek, it is a clear water stream about fifty feet wide. It flows with a strong current and has a fine gravel bed. The bar at the mouth was prospected, but no indication of gold could be found. Below Gravel creek the Jackfish becomes very rapid and turns more towards the east; cut banks alternating with long sandy points; and ten miles below a portage of ninety paces is made across a point on the left hand side to avoid a big log jam. A mile and a half below this a second portage of 780 paces is made on the same side. Here we were led to suppose that the river ran underground, and although it does not actually do so, the huge pile of driftwood that has collected and lain there for years has become so filled in with sand and mud that it looks as if the river did run underground, and one can walk across dryshod. The same thing occurs again some three miles below where another portage 180 paces in length is made on the right hand bank of the river. These three portages are the only ones that have to be made in going down with the high water. Gravel creek.

The banks in the neighbourhood of the portages are about ten feet high and are everywhere wooded with fine large spruce, but about ten miles below, the river cuts into a sand bank forty feet high. From the top of this the country on both sides of the river is seen to be very flat with few rises. It is thickly wooded and the only openings to be seen are swamps. Below the cut sand-bank for about 15 miles the current is not strong and the river is very crooked; then we entered a long succession of rapids which continue for nearly 20 miles. The river in these rapids High sand bank.

passes between high hills wooded with poplar and Banksian pine, and we frequently saw cut banks of gravel or clay. Most of the rapids were navigable, as the volume of the water was considerably increased by the two large tributaries mentioned above. Near the end of these rapids I noticed several sulphur springs resembling those on the Little Buffalo river.

From this point to the Peace river the course of the stream is slightly north of east and is very crooked. No more rapids or log jams are met with, and the river winds through a deep wooded valley in which spruce is the prevailing forest tree. As the Peace river is approached, however, the valley widens to about half a mile, and the spruce is replaced almost entirely by poplars and particularly the balsam poplar.

Mouth of Jackfish river.

We reached the mouth of the Jackfish river on August 27, hoping to find some Indians there, but, although there are a few houses, some on each side of the stream, they were all unoccupied at the time. The Jackfish river is here nearly 50 yards wide, without visible current, and it enters the Peace river, as near as I could judge, about 15 miles above the rapids at Peace point and about 130 miles below Little Red river post.

From the mouth of the Jackfish we had the choice of two routes out to Edmonton, and selected the one *via* Peace river and Lesser Slave lake, as being the easier. So, after taking bearings on all prominent points in its neighbourhood, I closed my track-survey and left the Jackfish river on August 28 for Edmonton, reaching that place on October 9 and Winnipeg on October 13.

Acknowledgments due.

My acknowledgments are due to the officers of the Hudson's Bay Company on the Slave and Peace rivers for much kindness and assistance, and particularly to Mr. Brabant, of Fort Smith, where I made my headquarters while exploring the district west of that point.

The topography of the country travelled over is very uniform and simple, and the most pronounced feature is the steep escarpment at the base of which the brine springs are situated. If a cross section were taken from Fort Smith south-west to Cariboo mountain it would show--first, the comparatively narrow level region bordering the Slave river, dipping very slightly as we get into the Salt plain, then the abrupt rise of over 200 feet to the top of the escarpment, much broken near its edge by numerous deep sink-holes. Beyond this an almost level upland stretching to the Nini-shith hills, which rise 100 feet above the general level of the plain; then going south-westward of

these a gently undulating surface rising slightly to the height of land, then dipping again to the Jackfish river valley in which the stream has carved a smaller valley, then rising once more with a long easy slope to the Cariboo mountain.

With regard to the geology of the region, I may say that nearly the whole area is covered by rocks of Devonian age, though, as they are undisturbed and lie horizontally, it is only in a few places that exposures appear on the surface.

Gypsum and mineral tar.

At La Butte, on the Slave river, 40 miles above Smith Landing, there is an outcrop of limestone associated with some gypsum and mineral tar; but no fossils were found by which it could be compared with the exposures in the escarpment at the brine springs; lithologically and in their associations with beds of gypsum they appear very similar. At Stone island also, about 25 miles below La Butte, limestone is exposed, and is here seen to rest directly on rocks of Archæan age.

The escarpment already mentioned near the brine springs was examined in several places. Its greatest height above the Salt river was found to be 210 feet, dropping to 150 at the Little Buffalo river, and its general direction about north-west and south-east. Three miles north of the forks of Salt river, where cliffs are exposed, they are seen to consist entirely of limestone, lying horizontally. But one mile south of the forks a bed of gypsum 20 feet thick is exposed near the base, and interbedded with this is a thin layer of red clay, while underlying the gypsum, and seen in the bed of the Salt river is a thick deposit of clay. Near here are the brine springs, but it was impossible to determine the source of the salt. Specimens of the limestone and gypsum were collected, as well as a few fossils from the cliffs north of the forks.

Sink-holes examined.

Deep sink-holes were mentioned as occurring in several places, and particularly where the summer trail mounts the escarpment, on the sides and top behind the brine springs, and also below the falls on Buffalo river. In only one or two of the smaller and more recent holes behind the brine springs was any rock exposed on the sides, and in these cases it was limestone. In all the others examined, because they were of earlier formation, the sides were covered with surface deposits, and sloped sharply down to a point in the centre resembling a funnel. Some were wooded to the bottom, particularly those on the Little Buffalo river. The majority of them were dry in July, but some of the larger and deeper ones contained fresh water, and these

may be the source of supply for the brine springs, at the base of the escarpment. The amount of surface water has a very marked effect on the volume of the springs, and in the spring the flow is much greater than later in the summer. The sink-holes vary in depth from five feet to 50 feet or more. An isolated sink-hole 25 feet deep was seen along the trail near Flat Grass lake, and the broken nature of the surface here would seem to indicate it was underlaid by beds of gypsum.

Cliffs of limestone and impure gypsum.

Cliffs of impure gypsum ten feet high occur on the Little Buffalo river where it emerges from the face of the escarpment, and in the gorge above this we saw cliffs of massive limestone rising perpendicularly from the water to a height of 60 feet or more. Very thin beds of gypsum occur with the limestone ; the rock lies horizontally and contains few fossils. At the foot of the falls the cliffs are 100 feet high. Here the lower beds are very thick and contain a good deal of gypsum scattered in crystals throughout the rock, consequently are very soft, while the upper strata are much harder and lie in thin beds. Crystals of iron pyrites occur in the upper strata.

On the floor of the Salt plain, three miles and a half south of the forks is an outcrop of limestone over which the summer trail passes. A specimen of this is submitted as showing the extent to which decomposition has gone. The whole outcrop is honeycombed, leaving only a skeleton of the harder parts. Another example of weathering is shown in the igneous boulders scattered over the clay flats in the vicinity of this outcrop of limestone. The boulders are generally of granite and are so much eroded around the base for about six inches up that they now resemble large mushrooms.

No exposures of the older rocks occur on the Jackfish river, though a few miles below the Sulphur springs large angular blocks of limestone are so common that the rock in places cannot be far beneath the surface. Recent deposits of sand and gravel however, are frequent in the lower part of the river. Exposures of clay occur just below the Sulphar springs and these are overlaid by about 20 feet of sand in which thin beds of peat occur.

Evidence of glacial action.

Evidences of glaciation in the form of numerous travelled erratics are everywhere visible, and particularly on the portage over the height of land between the Little Buffalo and Jackfish rivers. Nearly all of the rapids in each of these rivers are formed by accumulations of glacial boulders. No glacial striæ, however, were seen on any of the exposures of limestone. The Nini-sheth hills are very probably eskers, and seem to have no definite regularity. They are composed of fine sand

and have a general direction of nearly true north and south. On the north side of the Little Buffalo river they merge into one broad ridge, while on the south side they are split up into several rather sharp ridges, which again almost coalesce so as to inclose a large basin-shaped hollow, which was at one time occupied by water, but is now an almost dry muskeg. Similar smaller ridges occur on the Jackfish river about Jackfish lake.

NOTE.—All bearings mentioned in the above report are magnetic.

THE BLAIRMORE-FRANK COAL-FIELDS.

Mr. W. W. Leach.

The Blairmore-Frank coal-fields are situated a few miles east of the summit of Crows Nest Pass and are separated from the Crows Nest Coal-field proper by the main range of the Rocky mountains. To the south they are cut off by the Devono-Carboniferous rocks of the Flathead range. To the north, the limit of coal-bearing rocks is not as yet defined, but it is certain that it extends a considerable distance north of the present map. Eastward the belt of Lower Cretaceous coal-bearing rocks extends about fourteen miles from Crows Nest lake, when it is overlaid by rocks of Upper Cretaceous and Laramie age, also coal-bearing, but to a lesser extent. The accompanying map shows part of the latter formation. Area of field-work.

The existence of valuable coal deposits in this district was noted by Dr. Dawson in his 'Report on the region in the vicinity of the Bow and Belly rivers (*See* Report of Progress, 1882–84, pages 101c and 103c); and again in his report on that portion of the Rocky Mts., between latitudes 49° and 51°30′, (*See* Annual Report, 1885, pages 58B and 69B.)

Up to within the last two or three years very little had been done to exploit these fields, lack of transportation facilities being the chief drawback; the construction of the Crows Nest Branch of the Canadian Pacific Railway, however, crossing as it does the coal-bearing strata almost at right angles, has removed this difficulty; and within the past few years a great deal of work has been done, chiefly prospecting and surface stripping, so that it is now known that the productive coal measures are very much more extensive than was at first anticipated. Prospecting.

This region, within the boundaries examined this year (viz: Tps. 7, 8, 9 and 10, R. 2, 3, 4 and 5 west of the 5th Meridian) is, roughly speaking, divided into almost equal parts by the Livingstone range. General description.

To the west of this range and between it and the main range of the Rockies the country is somewhat rough and broken, and generally timbered. To the east of the Livingstone range the character of the country changes abruptly, the rough wooded hills giving place to low, rounded, grassy ridges, gradually decreasing in height until the open prairie valley of the Old Man river is reached. The Livingstone range itself is a rather remarkable anticlinal ridge, unbroken except where the Crows Nest and Old Man rivers have cut narrow gorge-like channels which are locally known as 'Gaps.' North of the 'Gap' of the Old Man river the range appears to continne for some miles. To the south, the Livingstone range (proper) ends at the Crows Nest river, although Bluff and Turtle mountains may be considered as a spur from the main range.

Direction of valleys.

The general direction of the valleys and ridges throughout this area is north and south, coinciding with the strike of the rocks, and the Crows Nest and the uppper part of the Old Man rivers cut the strata at nearly right angles.

Horizon of rocks.

The rocks of this region may be divided into three main divisions, viz: the Devono-Carboniferous, the Middle and Lower Cretaceous, and the Upper Cretaceous, in which may possibly be included part of the Laramie; of these, the two latter are coal-bearing.

The Devono-Carboniferous rocks consist principally of limestone with some beds of quartzite towards the top.

Cretaceous.

By far the most important series in this area from an economic standpoint, is the second division or Middle and Lower Cretaceous, which includes the principal coal seams. Wherever seen these beds appear conformable with the Upper Cretaceous and Laramie, so that until the country has been examined in greater detail and the fossils collected determined, it is impossible to draw a clearly defined line between this and the third division. For descriptive purposes, however, it will be assumed here that the volcanic intercalation, mentioned hereafter, represents the top of this second division.

Lower Cretaceous.

The principal rocks in these beds in ascending order are as follows, the various thicknesses given being only approximate:—

1. Gray and black shales with a few thin arenaceous beds, 700 feet.

Thickness of divisions.

2. Productive coal measures, 740 feet.

3. Hard cherty conglomerate; in parts replaced by very hard silicious sandstone, 30 feet.

4. Light-coloured sandy shales and shaly sandstones with some characteristic dark greenish and purplish shaly sandstone and massive seal-brown weathering dolomitic sandstone. One thin bed of shaly limestone was noted in several widely separated localities and may prove of value as determining a definite horizon. Just below the volcanics, near Ma Butte, a bed of hard cherty conglomerate was seen; this was much finer grained than that occurring above the coal and was not noted elsewhere, 1,850 feet.

5. Volcanics, consisting essentially of a very important intercalation of volcanic ash rocks and agglomerates. They vary greatly in thickness, apparently attaining their greatest development between Ma Butte and the point where they cross the railway, about three miles and a half below Crows Nest lake, thinning out rapidly to the east. Their maximum thickness is probably not more than 1,500 feet.

These rocks were found of great value as forming a reference horizon for working out the faulting and folding of the region. They vary greatly in texture and in general appearance and may prove of considerable interest when examined under the microscope.

In comparing the Middle and Lower Cretaceous rocks of this area with those of the Crows Nest coal-field, a general similarity is at once seen, with, however, a very marked diminution in thickness in the rocks of this district. This is particularly noticeable in the case of the lower dark shales underlying the coal measures, which here represent the 'Fernie shales' of the Crows Nest field.

No attempt has been made to obtain a complete section of the rocks of the third division. Owing to their soft, readily-weathering nature, exposures are less frequent than in the lower beds, and especially to the east of the Livingstone range, they have been tremendously crumpled and contorted so that a great amount of detailed work will be required to obtain even an approximate section of them.

Middle Cretaceous.

Immediately above the volcanics occurs a considerable thickness of gray and black shales, in places rusty-weathering, with at least two narrow beds of hard silicious sandstone. These are followed by an unknown, but probably great, thickness of soft light-coloured sandstones, varying in texture but generally rather coarse-grained. Towards the top these are interbedded with black and gray shales and at least two seams of coal.

General section along railway.

The geological structure of this area is somewhat complex, much faulting and folding being in evidence. Following the line of railway

across the map-sheet from west to east the section shown would be approximately as follows: About one mile west from the east end of Crows Nest lake the junction of the Devono-Carboniferous limestone, which forms the back bone of the main range of the Rockies, with the Upper Cretaceous beds, is met with. This contact is evidently a faulted one, the limestone dipping about 30° west while the Cretaceous sandstones and shales have irregular westerly dips at high angles. About two miles east of this point the dip flattens until the strata are nearly horizontal, but continuing in an easterly direction, westerly dips are again met with, gradually increasing to a maximum of about 30°. At a point about three miles and a half east of the lake the volcanics are crossed. These are underlain by sandstones and sandy shales to a point a short way west of the mouth of McGillivray creek, where the conglomerate and underlying coal measures are seen dipping west 30°. From the contact with the limestone to this point the series is evidently a regularly descending one. Near the mouth of McGillivray creek, however, an extensive fault occurs with eastern downthrow, since from here easterly to a point about half a mile west of Blairmore station the above series is repeated, the coal measures outcropping at this point, dipping about 60° to the west. Only one seam, the upper, has been discovered here, the lower seams apparently having been cut off by another fault with similar easterly downthrow. The beds overlying the coal measures follow with westerly dips to a point just east of Blairmore station where the coal measures are again met with. From the base of the coal measures to the contact with the Devono-Carboniferous limestone of Bluff and Turtle mountains the surface is covered, but is probably underlain by the lower dark shales seen elsewhere underlying the coal seams.

Bluff and Turtle mountains.

Bluff and Turtle mountains lie along the axis of what is probably a compressed anticline slightly overturned to the east, the Cretaceous rocks having been eroded away, leaving the underlying Devono-Carboniferous limestone exposed to within a short distance of Frank station, when the coal measures are again encountered dipping west at about 85°. Here, however, the thickness of strata between the conglomerate overlying the coal and the limestone is very much less than that seen elsewhere between the same beds, giving the impression that a fault exists at the contact of the limestone and the Cretaceous rocks.

Frank to Byron creek.

From Frank eastward to near the mouth of Byron creek a rather wide flat syncline is crossed, the coal reappearing on the axis of a sharp anticline at this point. This is followed by another similar syncline and anticline, the coal, as before, just coming to the surface on the axis of the anticline. Still another syncline follows, the coal

measures outcropping at the old Livingstone mine. A few hundred feet to the east of this old working a fault must occur with the usual easterly downthrow, the light-coloured soft sandstones of the upper beds appearing again. From this point to the eastern limit of the sheet these rocks continue, but are so much folded and crumpled that no attempt will be made to describe their attitude in detail. It may be mentioned, however, that coal seams were noted at two or three points, and are probably the same seams repeated by folding several times.

Section across northern portion.

A section across the northern part of the map-sheet will show a considerable diversity from the above, though in general the main features are alike. Thus, between the main range and the Livingstone range a series of faults occur with uniform easterly downthrow and some large folds, usually more or less overturned to the east, resulting in almost invariable westerly dips. East of the Livingstone range a narrow strip of Lower Cretaceous rocks with some coal is found, followed by the Upper Cretaceous and Laramie rocks much disturbed; both the contact of the Devono-Carboniferous limestone of the Livingstone range and the Lower Cretaceous to the east, and that between the Lower and Upper Cretaceous being faulted.

Two sections across the coal-bearing rocks were measured, one at least, that at Cat mountain, being fairly complete, although it is possible that other seams may occur below the last one noted.

Section at Cat mountain.

Cat mountain is situated on the west flank of the Livingstone range, about one mile south-east of the junction of Racehorse and Daisy creeks. The results obtained are as follows, given in descending order:

		Feet.	Inches.
1.	Hard cherty conglomerate	9	6
2.	Shaly sandstone	9	3
3.	Black shale	4	0
4.	*Coal* (impure)	8	6
5.	Black and gray shale	24	0
6.	Hard light sandstone	27	9
7.	Gray and black shale	4	0
8.	*Coal*	4	0
9.	Sandstone	13	0
10.	Gray shale	2	0
11.	*Coal*	3	6
12.	Gray shale	13	6
13.	Sandstone	4	6
14.	Black shale	1	0

	Feet.	Inches.
15. *Coal*	3	6
16. Gray and black shale	24	0
17. *Coal*	8	9
18. Gray shale	1	0
19. *Coal*	10	0
20. Gray shale	2	6
21. *Coal*	2	6
22. Hard, light sandstone	65	0
23. Gray shale	8	9
24. *Coal*	5	9
25. Hard, light sandstone	52	0
26. Black shale	9	6
27. Sandstone	1	6
28. Gray shale	12	3
29. Sandstone	10	0
30. Gray shale	11	6
31. *Coal*	5	6
32, Sandstone with a little shale	44	6
33. *Coal*	15	3
34. Gray shale	9	0
35. *Coal*	6	9
36. Gray shale	3	9
37. Hard, light gray sandstone	41	0
38. Black and carbonaceous shale and some coal	8	0
39. Sandstone	1	6
40. Black and carbonaceous shale and some coal	14	0
41. Sandstone	2	0
42. Gray shale	8	0
43. Sandstone	2	0
44. Gray shale and ironstone bands	11	0
45. *Coal* (impure)	4	0
46. Gray shale	23	0
47. Sandstone	2	0
48. *Coal*	5	6
49. Gray shale	5	0
50. *Coal*	6	3
51. Shale	0	6
52. *Coal*	9	9
53. Shale	1	0
54. *Coal* (impure)	3	3
55. Gray shale	7	0

	Feet.	Inches.
56. *Coal*	8	0
57. Shale	0	6
58. *Coal*	4	0
59. Shale	0	4
60. *Coal*	1	9
61. Shale	0	6
62. *Coal*	7	6
63. Gray shale	21	8
64. Sandstone	1	0
65. Gray and black shale	2	9
66. Black and carbonaceous shale and some coal	4	0
67. Gray shale	15	0
68. Yellow-weathering sandstone	1	3
69. Gray shale	10	0
70. Hard grey sandstone	16	0
71. *Coal*	1	3
72. Gray shale	5	0
73. Sandstone	45	0
74. Black and gray shale	..	..
Total	742	0
Total *coal*	125	3

The second or Byron creek section is probably not complete, the lower seams being wanting. Owing to the thick drift covering and the lateness of the season, it was found impossible to strip the surface any farther down. The section given below was measured on the east side of Byron creek near its head. As in the first section, the order is descending:— Byron creek section.

	Feet.	Inches.
1. Hard light-coloured sandstone; light conglomerate in places	44	0
2. Gray and black shales, shaly sandstone and a little coal	26	3
3. Covered	11	6
4. Hard grey sandstone	2	9
5. Black shale	1	6
6. *Coal* (rather impure)	9	9
7. Black and gray shale and covered	33	0
8. Hard light-coloured sandstone	16	0
9. Black and gray shale	8	0
10. *Coal*	5	6

	Feet.	Inches.
11. Gray shale and shaly sandstone and covered	60	0
12. *Coal*	8	0
13. Gray shale	1	9
14. *Coal*	9	0
15. Gray shale	14	0
16. Gray shale and covered	36	0
17. Gray shale	5	0
18. *Coal*	8	6
19. Gray shale	1	0
20. *Coal*	12	0
21. Gray and black shale and shaly sandstone	5	9
22. *Coal*	8	6
23. Gray and carbonaceous shale	1	6
24. *Coal*	3	3
25. Gray shale	0	6
26. *Coal* (partly shaly)	10	0
27. Gray shale and covered	29	6
28. *Coal*	16	0
29. Hard light gray sandstone	41	0
30. Covered	36	0
31. Sandstone	3	0
32. *Coal*	11	3
33. Sandstone	..	..
Total	479	9
Total *coal*	101	9

It will be noticed that very little resemblance exists between these two sections. Taking into consideration, however, the fact that the two points are nearly twenty-three miles apart, much uniformity was not to be expected. Owing to the kindness of Mr. H. T. Collett, the following partial section measured by him was obtained. These measurements were made on McGillivray ridge and are of special interest in connection with the two previous sections as showing the persistency of the coal seams throughout a large area. Mr. Collett's section is as follows, in descending order:—

Section on McGillivray ridge.

	Feet.	Inches.
1. Conglomerate	20	0
2. *Coal*	2	6
3. Sandstone and shale	20	0
4. *Coal*	5	0
5. Shale	10	0
6. *Coal*	5	0

	Feet.	Inches.
7. Sandstone	48	0
8. *Coal*	25	0
9. Shale	2	0
10. *Coal*	13	0
11. Shale	..	..
Total	150	6
Total *coal*	50	6

No analyses have as yet been made of the samples of coal collected this year, and it is probable that the quality will be found to vary considerably in the coal from the various seams as well as in the coal from the same seams in different parts of the field. Generally speaking, however, the coal throughout the district is apparently of good quality, resembling very much in appearance that from the Crows Nest coal-fields. The following partial analyses of coal from the Gold creek collieries, kindly furnished by Mr. R. Green, may prove of interest:—

Analyses of coals.

Moisture.	Volatile Combustible Matter.	Ash.
1. Not over one per cent	24	8
2. "	23	8
3. "	24	8·5
4. "	24	7·6
5. "	24	8·5

It will be seen from the above that this is a very fair bituminous coal. The following analyses by Dr. Hoffmann of this department are from specimens collected by Dr. Dawson in previous years:—

Locality.	Hydroscopic Water.	Volatile Combustible Matter.	Fixed Carbon.	Ash.
1. North-west branch Old Man river, 8 ft. seam	1·24	24·62	66·61	7·53
2. Old Man river, two miles below 'Gap,' 5 ft. seam	1·75	19·99	58·40	19·86
3. Crows Nest river, two miles below falls (upper seam 3 ft.).	3·27	32·53	44·38	19·82
4. Crows Nest river, two miles below falls (lower seam 3 ft.).	2·36	40·66	47·78	9·20

(*See* Report of Progress, 1882-84, pages 33, 34 and 35M and Annual Report, 1885, page 9M).

Of the above analyses the first two are from coals of Lower Cretaceous age, while the latter two are from Laramie or Upper Cretaceous coals.

Canadian-American Coal and Coke Company.

The most highly developed property in this district is that of the Canadian-American Coal and Coke Company. This company is operating a mine near Frank on the east flank of Turtle mountain. The seam is the upper one of the series and varies from nine to twelve feet in thickness, dipping to the west at about 83°, the strata being here slightly overturned. At the time of my visit a main entry had been driven in on the seam a distance of 4,500 feet, in addition to which there are two other drifts, one above and the other below. This company has been producing coal for over a year and during the past summer their output has been about 500 tons a day; it is expected, however, that this output will be largely increased within a short time.

This coal is of excellent quality for steaming purposes and is largely used by the Canadian Pacific Railway Co. on their locomotives, though it is reported to be rather high in ash.

A block of six coke ovens was built but is not now in operation.

Gold creek collieries.

The Gold creek collieries, operated by the United Gold Fields of British Columbia, are situated on Gold creek about 3½ miles above the town of Frank. A spur line of railway has just been built from the Crows Nest branch of the Canadian Pacific Railway to the mines. At the time of my visit no shipments had been made, the railway not then being completed, but development work was in progress, a main cross-cut tunnel having been driven a distance of 394 feet and a tipple being under construction. The following section of the main tunnel from the conglomerate to the end was kindly furnished by Mr. Caudron of the company :—

Section.

	Feet.	Inches.
1. Conglomérate	1	1
2. Sandstone	3	2
3. Conglomerate	6	5
4. Sandstone	21	8
5. Shale	2	0
6. *Coal*	0	6
7. Shale	0	3
8. *Coal*	1	5
9. Shale with a little coal	2	11
10. Sandstone	2	9

		Feet.	Inches.
11.	Shale	0	4
12.	Thin-bedded sandstone	12	2
13.	Gray shale	5	7
14.	*Coal*	2	0
15.	Shale	0	8
16.	Sandstone	8	6
17.	Shale	6	3
18.	*Coal*	0	1
19.	Shale	1	0
20.	Sandstone	4	3
21.	Shale	5	5
22.	*Coal*	3	3
23.	Shale	0	3
24.	*Coal*	4	7
	Total	96	6

Besides this the company are opening up several seams on both sides of the valley, about one mile and a-half above the main entry.

The valley of Gold creek here occupies the centre of a rather sharp syncline, the coal measures outcropping on either side, so that it is possible, by means of short cross-cut tunnels to attack the coal on both sides of the creek.

In this part of the district the coal measures appear to have suffered a considerable diminution in thickness, as will be seen by comparing the section above with those of Cat mountain and Byron creek. The coal, however, appears to be of excellent quality and the seams of good workable size.

This company has also done a large amount of prospecting on Grassy mountain, which lies directly north of Bluff mountain and forms the axis of the northern extension of the Turtle-Bluff mountain anticline. A great number of coal seams have been uncovered at this point, but, in all probability, in many cases these are the same seams repeated several times by sharp folding. **Grassy mountain.**

This company expects to construct a number of coke ovens during the coming year.

Outside of the workings of these two companies, the work done has been largely of a prospecting nature. Among others the Newport-Paulson property, situated on York creek about two miles above its mouth, on the most westerly outcrop of the coal measures, may be **York creek.**

mentioned. Three seams of $17\frac{1}{2}$, 12 and 8 feet thickness respectively have been opened up by short tunnels showing good coal in each case; the strata here dip about 35° to 40° west.

Lyon creek. Considerable work has been done by the Hastings Exploration Co. on Lyon creek, several large seams having been opened up. The tunnels, however, have caved in so that it was impossible to obtain a section here. These openings are on the same outcrop as are those on the Newport-Paulson property.

Blairmore. About half a mile north of the town of Blairmore Messrs. Proctor and Fishburn have driven a cross-cut tunnel cutting two seams, besides having done a good deal of surface stripping.

A wagon road was built last summer up Byron creek and a number of seams were uncovered near the head of the creek; the Byron creek section on another page will show the result obtained here.

Byron creek. On the McVittie-Leitch property, near the mouth of Byron creek, a number of seams have been uncovered by open cuts. The coal apparently outcrops here on the crest of a sharp anticline and it is probable that some of the seams are repeated.

Upper Cretaceous coals. The coals and lignites of the Upper Cretaceous and Laramie have been opened up in several places, chiefly to supply the local demand for domestic fuel. In most cases however, the highly contorted condition of the strata renders mining difficult and uncertain. The most important of these openings is on the Galbraith property, about two miles below the falls on the Crows Nest river, where small shipments are being made more or less regularly. A short distance below this, on the Holway property, a shaft has been sunk on what is probably one of the same seams. This is now abandoned. Several other openings were seen, two on the Old Man river and one at Livingstone. in all of these the work done has been on a very small scale, shipments having been made intermittently for local use.

As it is now proved without a doubt that very large deposits of coal exist in this area, and success in future mining operations will depend largely on the selection of the best available sites. In this connection several factors have to be taken into consideration, such as the quality of the coal, transportation facilities, the absence of faulting, and the altitude of the coal seams themselves; with regard to the latter, it is the general opinion among local mining men that, for the present at least, the coal below the level of the valleys cannot be profitably extracted in competition with that won by drifting into the mountain sides and requiring no hoisting or pumping machinery.

The limestone of Bluff and Turtle mountains is now being utilized to a certain extent, several limekilns being in operation on both sides of the railway in the Crows Nest Gap. This rock is said to make a very good lime for building purposes. Limekilns.

Several sulphur springs were noted as occurring along the eastern flank of the Livingstone range near the contact of the limestone and the Cretaceous rocks. The most important of these is situated about one mile west of Frank, just south of the railway, where a sanatorium hotel has been erected. Sulphur springs.

In addition to the geological work done during the season, a topographical survey was carried on by means of transit triangulation, panoramic sketches, and traverses of wagon roads, trails, etc. Enough information was obtained to compile a contoured map of the greater part of the area. Topographic work.

A number of fossils were collected, chiefly from the Upper Cretaceous and Laramie beds, with a few from the lower dark shales and some fossil plants from the coal measures. None of these have as yet been determined. Fossils.

During the past year a great deal of interest has been taken in the possible futurê development of iron industries both in this district and in British Columbia. In view of this, a flying trip was made to the Bull river iron deposits situated on the south-east side of Bull river, about ten miles north of Jaffray station on the Crows Nest branch, and at an elevation of about 3,000 feet above the valley. Bull river iron deposits.

The base of the mountain consists of Cambrian quartzites and altered argillites dipping at low angles to the east. Towards the top these are succeeded by dolomites, interbedded with highly altered argillites, apparently comformable with the lower beds and probably also of Cambrian age. In a number of these upper beds the original constituents have been replaced in varying degrees by hematite ore. The work done consists entirely of surface stripping and open cuts, more or less disconnected, so that until further work is done it is impossible to form an opinion as to the continuity of the ore in the several beds, nor was the source of the ore made clear, though it is certain that mineralization has taken place over a considerable area. The ore appears to be of good quality, though in places, somewhat silicious. The maximum thickness of clear ore seen was about five feet.

EASTERN ASSINIBOIA AND SOUTHERN MANITOBA.

Mr. D. B. Dowling.

Lignite of Souris river and Turtle mountain.

The treeless areas of Assiniboia and Manitoba are fast filling up with settlers and, as the fuel supply is an important item in the well-being and permanency of settlement, an inquiry into the conditions and extent of the coal mining industry in these districts was thought advisable. The mining of lignite in the Souris valley is well established, but no examination, of this district had been made since 1880, when Dr. Selwyn superintended the putting down of several bore-holes to test the eastern limit of the deposit. In Manitoba coal seams had been found on the flank of the Turtle mountain, and mention of these was made in the Summary Report of this Department for 1890–91, but these were isolated instances and an endeavour to correlate the seams and outline their possible outcrop seemed of present importance.

Besides the examination of the coal-field of the Souris and Turtle mountain, inquiries were made relative to some other industries in Manitoba, such as the making of brick, cement and plaster. The report which follows contains a summary of the field operations for the season with some general notes on the extent and topography of the Turtle mountain coal field, illustrated by a contoured plan of the northern flank of this hill.

In pursuance of instructions I proceeded westward, arriving in Winnipeg June 7. Here I was joined by Mr. Fred. Bell who was to be my assistant for the season. At Brandon we obtained a team and light wagon, intending to drive through the district southward to the Turtle mountain and observe any outcrops of the rocks which are beneath the Laramie or Lignite Tertiary that forms the summit of this elevation. Owing to the wet state of the roads, after visiting some exposures in the vicinity of Souris, I determined to ship the outfit to Estevan where I learned the roads were in better condition. In this way I could make the examination of the Souris coal-field at first and later during the summer that in Manitoba to better advantage.

Explorations near Estevan.

On our arrival in Estevan we had evidence of the influx of land seekers in the crowded state of the hotels and the activity of the land agents and those in the livery business. We established our camp in the valley below the town and spent two weeks in exploring the banks of the stream between Estevan and Roche Percée. While there the stream rose in flood and prevented our driving across, so that much of our work on the south side was performed on foot.

With the railway levels as a base, elevations were obtained with aneroid barometers and a series of levels (with an 18-inch spirit level) were made across the valley at the coal mines below Roche Percée. These were connected with the railway levels at the latter station and also carried east as far as the site of the bore-hole of 1880, located on the south-east quarter of Section 6, Tp. 2, Range 5 west of the Second Meridian. **Topographic work.**

From heights thus obtained a contoured plan of the area examined was roughly prepared showing intervals of ten feet, and from this a model has since been constructed for the purpose of illustration.

The coal horizons were traced in almost continuous lines from Estevan eastward for 14 miles and along the valleys of the Souris and Short creek to the International boundary.

After having completed the mapping of the field and the measurement of all the natural sections, we drove eastward by the trail near the railway to the Turtle mountain, where, on August 4, I began running a series of instrumental levellings to determine the elevation of all the known occurrences of lignite and thus obtain some basis from which to correlate the seams and find the probable slope of the horizon. In this endeavour we levelled over 52 miles of roads, and by driving from these known points were able to determine by barometer in a satisfactory way the contour of a wide belt around the north flank of the hills. As natural exposures in this country are rare, much of our information was obtained from those residents who had in sinking wells touched or passed through seams of lignite. In the mountain itself very little information could be gained except in isolated cases, owing to the lack of settlement and scarcity of roads. A more detailed account of the information thus gained, illustrated by a contoured plan of the lower slope of the hill, is appended. **North flank of Turtle mountain.**

On September 8, I disbanded the party at Boissevain and sold our horses and wagon, intending to visit such other localities as could be reached by train.

A mantle of sand and gravel is found in varying thickness over the area formerly occupied by the extinct Lake Souris. This lake was called into existence at the close of the glacial period when the edge of the ice sheet had melted back to the latitude of the Tiger hills and in the hollow in its front had accumulated water from the melting ice. As the natural outlet was thus closed by the ice an overflow to the south-east resulted, and as the fall down the face of the Pembina mountain was very steep, the erosion was rapid and a deep channel **Superficial deposits in southern Manitoba.**

was soon scoured out which now forms the valley in which a small stream, the Pembina river, flows. No distinct traces of shore lines are noticeable along the face of the Turtle mountain, but terraces and irregular hills of gravel and sand are found which were probably shallow water deposits. Ridges of this nature were noticed north of Whitewater lake, indicating a rise which approximates in elevation the gravel and sand terraces of the lower flank of the mountain occurring at about the 1,700 feet level. In the road cutting south of Boissevain, gravel and sand deposits are found resting on boulder clay near the top of an isolated hill.

Eastward along the railway the Cretaceous shales begin to appear in the beds of creeks crossed. At first, the shale exposed seems not to be in place but washed from the boulder clay, as, at the creek crossing between Ninga and Killarney, they were searched for but, although the cutting shows plenty of the gray shale, it is on the surface and has been washed out. The first definite exposure is at Crystal City, where there is a very thin coating of till.

Exposures from Boissevain to Larivière.

The following notes regarding exposures seen from the train are here added. From Boissevain to Ninga the railway runs in sight of the foot of the slope of the hills to the south, which consist principally of a broken terrace at about a mile south of the track. Just above Ninga there is a gravel pit. About two miles east of the latter station there are some hills north of the track which have the appearance of being dumps of gravel. At Killarney there is a series of ridges which also appear to be of gravel. They run parallel to the sides of the narrow lake, one on each side, though the southern one seems to be on the south side of the White Mud river. The railway cutting at Holmfield shows boulder clay covered, at a mile east of the station, by gravel. At the river at Cartwright there are no exposures but the cutting shows gravel and a little shale, and a mile east of the river sand is exposed in a ballast pit. All over the strip between this and Clearwater there are many ridges which are bare of stones. These are possibly gravel or elevations left from the denudation of the underlying shales. At Mather the gravel deposits must be thin, as boulders show thickly on the surface and in the slough near the town. At Clearwater there are several exposures of shale in the river bed, but it is not seen in the railway cuttings and, as mentioned above, the first appearance near the surface is at Crystal City. All along the grade descending into the Pembina valley, good exposures of the shales of the upper part of Pembina mountain series as described by Dr. G. M. Dawson, are seen wherever excavations have been made for the railway. This shows the absence in the valley of any thickness of boulder clay and

Pembina valley.

is a proof that the removal of the rocks in forming the valley was after the deposition of the boulder clay.

The lower division of the shales of the Cretaceous is not so homogenous in composition, as it includes clay ironstone, rusty clay shales, and soft black clay shales, in which there are many fragments of fish remains and some carbonaceous matter. These beds outcrop lower down the valley and at the locality visited, on section 14, township 2, they formed nearly the whole of a small cliff on the western bank of the river.

The calcareous clays of the Niobrara division should be exposed in the lower part of this valley, but I was not able to obtain definite information as to the location of any exposures. Where the Canadian Northern Railway mounts the Pembina escarpment at Arnold, light yellowish calcareous clays probably of this horizon are exposed in a small ravine. Beneath are gray calcareous clays in which inoceramus and oyster shells, as well as a variety of fish remains, are common. These species are supposed to be characteristic of the Niobrara.

The Union Mining Co.'s plaster mill on Lake Manitoba at Gypsumville and the quarries situated ten miles to the northeast were visited by means of the company's steamer from Westbourne. A short visit was also made to the quarries at Stonewall, at the request of Dr. Whiteaves, to add if possible to our list of fossils from that locality. Several forms were obtained, among which appears a new species of coiled cephalopod. I desire to acknowledge the efficient aid I received from Mr. F. C. Bell in the instrumental work accomplished during the season.

I returned to Ottawa September 29.

CEMENT.

Mention has been made of the occurrence of rocks in the Pembina escarpment which are referred to the Niobrara. These are chiefly calcareous clays, as distinguished from the clays both above and below them in which there is hardly a trace of lime. The exposure at Arnold by comparison with the railway levels, is situated between 1,200 and 1,275 feet above tide and is continued northward on the Boyne river or its extension in the township to the north-west. On section 15, township 6, range 8, marlite and calcareous clays are found between 1,220 and 1,320 feet above tide near the extension of a new line from Carmen to Somerset. Below them on section 13 of the same township between 1,120 and 1,220 feet, clays without lime are found. Cement in Manitoba.

Niobrara shales.

On the banks of the Assiniboine river directly north of Treherne, Mr. Tyrrell recognized the Niobrara at what is supposed to be a much lower horizon, as also the calcareous clays penetrated in the well-boring at Morden. This may indicate a thickening of the formation and the introduction of a band of dark clay between the members of the upper part and the lower.

Cement works at Arnold.

These deposits are of importance in a commercial sense as they contain nearly all the ingredients required tor the composition of cement. At Arnold, the Manitoba Union Mining Co. have established a small plant for the manufacture of cement. Their kiln and grinding house are situated in the ravine and are at present making a common grade of cement from the lower gray beds which are mined by a tunnel. The experiments made by this firm point to the lack of a pure lime in the rock now used. In other localities the upper part of this formation has proven very rich in lime, and beds approximating the correct percentage will no doubt be found above those now used. Experimental briquettes with an added percentage of imported lime were tested at the time of my visit and went as high as 500 lbs. per square inch after three months in water. This would seem to approach the strength of average Portland cement.

Cement rocks.

The section of the rocks exposed here shows fifty feet of light-coloured clays, generally light yellow and brown near the upper part of the hill and gray or bluish-gray at the bottom of the exposure. Dark streaks in the upper yellow part suggest carbonaceous matter, but many of them are found to be of a dark, almost black, clay without lime. The average sample of the yellow beds compared with the bluish-gray of those in the mine, show, according to the subjoined note, a percentage of lime which seems very constant and the assumption is that this thickness of 50 feet exposed in the hill-side might with advantage be all used without the expense which mining one bed imposes. The beds in the mine appear very uniform in texture, but the burnt specimens show in a marked manner that the beds are made up of thin plates differing in composition. The suggestion then that the whole mass be puddled seems reasonable, and to the uniform mixture then could be added such other elements as may be needed. The burning would also be more uniform if the material were pressed into bricks of a common form instead of a varied assortment of fragments large and small as at first attempted.

From the laboratory of the Survey, contributed by Dr. G. C. Hoffmann :—

'Memo. *re* results of examination of two specimens of shale from Arnold, Man., collected by D. B. Dowling, 1902.

(a.) A dark bluish-gray shale, was found to contain:—Lime, 32·07 per cent, equivalent to carbonate of lime 57·27.

(b.) A brownish-yellow shale was found to contain :—Lime, 31·51 per cent, equivalent to carbonate of lime 56·27.

BRICK.

The clay generally spread over the surface beneath the soil has been utilized in many places to make a rough brick for domestic use. A finer grade, both as to colour and finish is required and is generally imported for the more pretentious buildings in the larger towns and cities. An effort to utilize the shales of the Pierre formation which are exposed in the higher part of the province is being made in the Pembina valley where a great thickness of the upper part of this formation is exposed in the sides of the valley. **Brick.** **Shales of Pembina valley.**

The shales of this upper part are of a light gray colour, in heavy beds which readily split up into thin sheets. No traces of fossils were observed and the rock seems to be wholly argillaceous with no calcite. At Lariviere, the station in the valley, a brick-making industry has been started. The shale is pulverized as it comes from the quarry and compressed in the dry form. These bricks are at once built into the kiln for burning. The plant with a complement of 17 men is capable of producing 30,000 bricks per day. This method of making brick from shale is in active operation in Pennsylvania and other states and it is expected that with some modification it will be a success here. The fuel used is a mixture of wood and lignite.

The shale of the Pierre formation is exposed in many localities both in Manitoba and the Territories. A sample of this from Souris, Manitoba, was tested in the Laboratory of the Survey and experimental bricks made which prove the fitness of the material. Dr. Hoffmann gives it as his opinion that they would make a good class of fire brick. The tests to which the material was subject are here given from the Report of Progress for the years 1880-82, p. 2 H ;— **Shale from Souris.**

'For the purpose of brick-making this material requires, agreeably with the present experience, no admixture whatever. In the following experiments it was simply ground to powder—which it readily admits of—mixed into a stiff paste with water, well pugged and then the moulding of the bricks proceeded with. By employing the material in a fine state of division, and forming the bricks under pressure, an article of very close texture may be ensured. The bricks after having been thoroughly dried, were finally burned in the muffle **Tests for brick making.**

of a cupelling furnace, at a full red heat. On examination they were found to have retained their form well, having neither warped nor cracked; they were firm and tough; the colour, a very pleasing one, may, perhaps, be best described as a very pale brownish-yellow. They were in no wise affected by protracted and repeated immersion in water.'

Fire brick.

'Other of these bricks were inserted in covered crucibles, and these latter placed in an air-furnace, the temperature of which was gradually raised, until, at the expiration of an hour, a white heat had been attained, at which temperature it was maintained for an additional two hours. On opening the crucible the bricks were found to have retained their original form intact; they had neither warped nor cracked, their edges remained perfectly sharp and showed no indication of having undergone even the most incipient fusion. Colour, a very pale reddish-brown.

'The foregoing experiments tend to show that this clay is well adapted for the manufacture of an excellent building brick, and further, lead to the inference, that it could also be advantageously employed for the manufacture of a good class of fire brick.'

PLASTER.

Plaster of Paris.

The gypsum deposits at the base of the Devonian, as exposed north of Lake St. Martin, are being utilized for the making of plaster. The deposits are worked in open quarries and the gypsum transported to the shore of Lake Manitoba, where it is ground and burned—shipment to the railway at Westbourne being made by steamer. As the gypsum deposits were first examined by Mr. J. B. Tyrrell in the summer of 1888, the description published by him in the Canadian Record of Science for April, 1889, might be here reproduced, as his general report contained but a passing remark. His visit was made on foot from Lake St. Martin and after passing through a somewhat level country a rough ridge situated on sections 13 and 23, Township 32, Range 9 west of the Principal Meridian, was reached and the following extracts from the above paper begin his description at this point:—'Following the ridge, still in a north-westerly direction, for a mile, the surface becomes very rugged and irregular, being broken by deep pits with steeply sloping sides. In this rough country, gypsum may be seen in numerous outcrops, being usually soft and crumbling from the effects of weathering, but in some cases it is still quite hard. The height of the tops of the knolls in this hilly area is about thirty-five feet above the eastern level plain, or sixty feet above Lake St. Martin. The breadth of the hilly country was not de-

Gypsum deposits east of Lake Manitoba.

termined, the Indian who accompanied us stated that it extended in a south-westerly direction, as far as a certain point on our journey of that day, which was about a mile and a half distant from where we were then standing, beyond which the level country began again.

'In a north-westerly direction the ridge was followed for two miles further, to a rather conspicuous hill a short distance north of the Ninth Base Line in section 2, Township 33, Range 9 west of the Principal Meridian. In this distance it appeared to be broken through by considerable gaps in several places, but where it was well marked, it invariably showed the irregular surface so characteristic of country underlain by gypsum deposits. In many places small caves would extend in from the bottoms or sides of the pits, some of which held beautifully clear cold water.

'This country is a famous winter hunting ground for the Indians, for in the autumn the bears retire to these caves, as being confortable quarters in which to pass the time until the following spring, and many of them are killed every year. Around the mouths of several of the caves could be seen marks of the axe, where the hunter had been obliged to widen the entrance to the cave to be able to get into it to secure his prey. The thickness of the exposures of gypsum in these holes and caves was nowhere very great, ranging as a rule from three feet to six feet six inches, but in none of them was the total thickness of the deposit seen.

Indian hunting ground.

'The hill at the furthest point to which the ridge was followed, rises as a rounded knob, twenty feet above its general level. This hill, like the others, appears to be composed of gypsum, as on its sides are holes extending down twenty feet below its top, in which beds of gypsum are well exposed.

'In the north-west corner of Township 32, Range 8, west of the Principal Meridian, is a rounded hill rising thirty-five feet above the plain, its greatest length being about 600 feet, and its greatest breadth 150 feet. Its surface is overgrown with small canoe-birch. Two holes, each about eight feet deep, have been dug by prospectors in this hill. One at the top shows, below a foot of decomposed material, seven feet of hard, compact, white anhydrite or 'bull plaster,' exhibiting a more or less nodular structure, and breaking on the surface into small irregular fragments. Very little bedding can be detected in the mass. The other hole is in the side of the hill fifteen feet lower down, and shows on top two and a half feet of white clay, consisting of decomposed anhydrite, below which is five feet and a half of white nodular anhydrite, similar to that in the other hole. This gives a thickness,

almost certainly, of twenty-two feet of this rock and it is not improbable that the hill is entirely composed of it.

'Again, just north of the Ninth Base Line and two miles east of the township corner, between Ranges 8 and 9, is a poplar-covered hill or ridge thirty feet high. In various places on this hill are exposures of snow-white gypsum, similar to what has been described above, showing in some cases a thickness of ten feet in one section. The most of it is massive or crypto-crystalline, and lies in regular beds which dip slightly towards the west. Some of the beds or layers however consist of beautifully crystalline clear colourless selenite, which is easily broken out in lamellar masses of considerable size. This is the mineral which, in the west, has been so often mistaken for mica.

Gypsum deposits east of Lake Manitoba.

'As far as examined the beds preserve a pretty constant character. Where they immediately underlie the surface, the country is very rough and hilly, and the prevailing poplar of the region is mixed with birch, or the spruce of the adjoining low-lying land is replaced by Banksian pine. The gypsum itself is generally very pure, of a dead white colour, and usually stratified in rather thin beds, which are either horizontal or dipping at a low angle. Among the massive beds, however, are many others, composed of crystals or crystal-masses, in which the crystals usually stand transverse to the planes of bedding. Some plates could doubtless be obtained from the crystal-masses sufficiently clear for optical purposes. No anhydrite was seen mixed with the gypsum, but one of the hills, as above stated, appeared to be composed entirely of it. It is much harder and tougher than the gypsum or hydrated sulphate of lime, is considerably heavier, has a roughly nodular, rather than a distinctly stratified structure, and is of a decidedly bluish tint.'

Quarries opened.

The bedded character of the gypsum is well seen in the quarries opened by the company. The one first worked is probably on the ridge followed by Mr. Tyrrell, and is in or near section 13. In this, a quarry 55 yards long has been opened and shows an average depth of ten feet. From this, judging by the cross section of the ends, there has been removed about 1,800 cubic feet of rock. Nearby another quarry not so well worked out, is about 40 yards long. Prospecting pits showing white anhydrite near the surface have not determined its depth, and, judging from the nodular and lenticular inclusions in the face of the quarry near, some of these prospecting holes may have touched some of the thin beds and do not necessarily preclude the presence of gypsum beneath. Other quarries are to be opened farther to the east and north.

The western limit to the uneven country underlain by the gypsum appears to be bounded by a small stream flowing south into the north end of Partridge-crop lake. So that a distance of ten miles intervenes between the deposit and the mill on Lake Manitoba. The rock is quarried and transported to the mill over a bush road by team. The mill is situated in a small bay just to the north of Davis point, and the material is piled in close proximity. As the shipping season is confined to the summer, enough gypsum has to be hauled to the mill during the winter to meet the estimated output for the next year. The grinding and roasting is by the usual burrstone and kettle and the shipments during this season, according to the manager, average 70 tons per week. This will probably be increased in the future.

Plaster mill.

Output.

As these beds belong to a horizon just below the Devonian, as in the western Ontario peninsula and in New York state, outcrops should be looked for in the country south of this locality and east of Lake Manitoba. The ridges west of Shoal lake and Stonewall might be predicted as possibly having concealed beneath the surface-covering, some of the beds of this deposit. Evidence of their extension to the west in shown in the boring on Vermilion river made by the Manitoba Oil Company, where at a depth of 550 feet, gypsum with a thickness of 15 feet was struck.

Probable extension of beds.

THE SOURIS COAL MINES.

The mapping of this field and a more extended report could not be accomplished in time for insertion here, but a brief note is given.

Souris coal mines.

In the vicinity of Estevan there are roughly three series of seams which are for convenience referred to as Upper, Middle and Lower seams. The Upper (4 ft.) seam is found all around Estevan at various shallow depths below the surface. It has been struck in many of the wells and has been worked along the outcrop by farmers and others in many places as far east as opposite the site of the bore-hole of 1880 in range 5. The seam maintains the average thickness of 4 ft. over most of this area. Though the quality of the lignite is generally inferior to that in the lower seam, its accessibility and even thickness renders it the more useful for purely local purposes. The Middle seam which has been burnt in many of the outcrops in the vicinity of Estevan and near Roche Percée, thins out very much. A small remainder of it has been mined out in an isolated hill in the valley at Estevan, and the seam in the old Dominion mine west of the town was probably on either this or the Upper seam locally thickened to 6 feet.

Seams in Souris district.

The Lower seam is separated into several smaller ones by clay partings of various thicknesses and is mined both beneath the town

Lower seams.

and eastward in the vicinity of Roche Percé. The quality is much better than in the upper ones and at the eastern end of the coal-field the clay partings have thinned out and eastward from the Hazzard mine, in which there is still a trace of the parting; in the Souris and Roche Percée mines there is a clear 8 feet seam of good lignite.

Output of mines. The mines in active operation here are under one management and the average output during the summer months amounted to about 100 tons daily. As the autumn approached, this increased and for part of the time trebled the summer output.

Extension of field north and south The extension of the seams northward toward the Souris branch of the C. P. Ry., was this year tested by an independent company having interests in property between the river and Bienfait. Owing to difficulties in penetrating some of the ironstone bands above the Lower seam several of their bores had to be abandoned, but enough was done to prove that over a large area, deep mining from the surface is feasible. Southward, the sections on Short creek and Souris river afford evidence of the continuation of workable seams to the Boundary line.

COAL IN THE DRIFT CLAY.

Coal in drift at Souris. At Souris, Manitoba, dark shales of Cretaceous age outcrop along the banks of the river near the town. About half a mile east, at the old rifle range, a very thin streak of coal had been found some years ago near the top of the formation but subsequent borings by the Manitoba government had proved that below this there was a great thickness of barren shale. Notwithstanding this, a few of the residents still had hopes of the ultimate discovery of coal in the vicinity and a farmer had commenced the construction of a tunnel into a mass of boulder clay. This probably was induced by the finding in the drift many small fragments of coal along with pebbles derived from a distant source. The man was persuaded to abandon the enterprise as the drift over a large part of the western part of Manitoba contains fragments of coal probably derived from the lowest member of the Cretaceous formation—the Dakota sandstone—which would outcrop along the foot of the Pembina and Riding mountain escarpment.

NOTES TO ACCOMPANY A CONTOURED PLAN OF THE LOWER SLOPE OF TURTLE MOUNTAIN, MANITOBA.

Mr. D. B. Dowling.

Explorations of areas covered by Cretaceous and Tertiary rocks on the plains have established the general fact that very little disturbance is to be found in the eastern part as indicated by tilting or faulting, and that in a general way the series of beds remains very nearly horizontal. Where there are known outcrops of lignite it would be most probable that its continuation would within certain limits be found along a line representing points of equal elevation. Coal in Turtle mountain.

In examining the outcrops along the slope of the Turtle mountain it is found that they are so meagre and few that an attempt to correlate the beds by such exposures would be hopeless. On the other hand, many of the residents have by well-boring obtained a certain amount of information relative to the underlying rocks which would, if supplemented by a knowledge of the orography of the district, be useful and might lead to some definite result in tracing seams throughout the district. Map of mountain.

The map submitted herewith is ruled to show intervals of 25 feet difference in elevation over the lower slope and 100 feet in the higher parts.

The notes submitted represent such information as it was possible to gain in the short time at our disposal.

The general character of such coal as was seen by us is very similar to that of the lignite which is now being used from the Souris field. It may prove not so homogeneous or compact but will undoubtedly be useful for local use. It probably will not stand very long or rough shipment. Housekeepers in Deloraine who had used the coal from the McArthur mine claim that it was equal to the Souris coal. Unfortunately no analyses are to hand by which to make comparison, but it may be assumed that the lignite will contain a high percentage of water and therefore slake on drying and it will be necessary to keep it stored in a closed bin or cellar.* Character of coal.

---

*NOTE.—An analysis of coal from the northern part of Dakota in the Turtle mountain shows the nature of a probably similar lignite. This is poorer in fixed carbon than that of the lower seams of the Souris field, but very similar to some of the upper ones.

Analysis by E. Whitfield :

Water	13·98
Volatile hydrocarbon	40·81
Fixed carbon	36·90
Ash	8·31
	100·00

—Bull. U. S. Geol. Surv. No. 27, p. 74.

The western slope of the Turtle mountain is considerably more abrupt than that to the north. From Goodlands, a station on the Waskada branch, a rise of 200 feet in three miles reaches the base of the steep slope of the mountain proper. To the south, the outline of the mountain follows a nearly north-and-south line, but as will be seen from the contours drawn on the accompanying plan, the lower slope is carried out more to the west and in places along the western edge of Township 1, Range 23, a narrow terrace is developed. It is beneath this terrace that the first coal seams found in the district are situated. Several streams that have their origin not far to the east of this terrace or come from a bay in the outline of the mountain, cut deep ravines where they issue from the edge of the terrace. A well dug in the bed of one of these ravines on Section 12, Township 1 Range 24, passed through several coal seams from which a running stream of water was obtained. This apparently, proved too wet to work, and another pit was sunk from higher ground about 150 yards to the north. From this, coal was raised by means of a farm engine and drawn to Deloraine in the winter by teams. This pit is known, locally as the Vaden mine and some notes on it were published by Dr. Selwyn in the Summary Report for 1890. In digging the well in the ravine, after passing through the surface deposits, a mass of broken coal five feet thick was passed through, but in the shaft for the mine this was not recorded, so that probably it was an accumulation of drift material derived from a small seam just above.

Section at Vaden mine.

Tp. 1, R. 24.

The section as obtained by Dr. Selwyn shortly after the well was dug is given below, with the elevation of the base of each member as deduced from levellings taken this season.

	Feet.	Inches.	Feet.	Inches.
Surface of ground	0	0	1773	6
Surface deposit	3	0	1770	6
Dark clay	4	0	1766	6
Coal	5	6	1761	0
Clay shale	10	0	1751	0
Coal	3	6	1747	6
Sandy brown shale	6	0	1741	6
Soft whitish brown shale	2	0	1739	6
Sandy clay	6	0	1733	6
Coal	1	6	1732	0
Friable whitish brown sand	12	0	1720	0
Bored from bottom of shaft sandstone	20	0	1700	0

Of the pit at the old mine Dr. Selwyn writes: * 'The coal was struck at 40 feet, 4 feet 6 inches thick, then 12 feet of sandy shale and thin bands of iron ore; coal 1 foot 6 inches; then bored 35 feet through sandy shale; total 78 feet 6 inches.'

* Summary Report, Geol. Surv. Can., 1890, p. 11A.

The elevation of the ground at the mouth of the pit is 1,794 feet above the sea. How near this is to the original surface is hard to determine, but from the above section it would seem that at about 1,754 feet a seam of coal 4 feet 6 inches was struck, so that the bottom of this would be at 1,749 feet 6 inches as compared with 1,747 feet 6 inches of the section in the flowing well. The bottom of the lower coal seam, 1 foot 7 inches thick, would be at 1,736 feet as compared with that in the well at 1,732 feet. These variations are due to the uneven thicknesses of the sandy clays and sandstones which intervene. The boring carried from the bottom of the shaft was probably down to the same bed as in the well or near to the 1,700 feet level*. The following elevations were determined in this vicinity: Top of bank on road north-east of mine, 1,842 feet 5 inches; on road bridge near mine, 1,784 feet 7 inches; on same road below Croyden school, 1,809 feet 7 inches; at flowing well near mine, 1,773 feet 9 inches; in bed of stream west about 50 yards in the north-west quarter of this section, 1,753 feet 5 inches. A flowing well at the last of the above points was dug into some coal in the bed of the creek not more than two feet below the surface, and on the north bank a caved-in pit was reported to have been sunk for coal. Further inquiry elicited the fact that the first coal taken out in the district came from this pit. Mr. Herman Mentz, who lives on the south-east quarter of Sec. 22, Tp. 1, R. 24, had, before the Vaden mine was opened, taken ten tons of coal from this pit at a depth of ten feet, or about two feet below the bed of the stream. The seam was four feet thick and, Mr. Mentz thought, tilted slightly to the north. If the bed was two feet below the bottom of the creek the elevation would be 1,751 feet, and it is probably the same seam as that in the mine between 1,751 and 1,747 feet.

First opening made on coal in sec. 12.

Below this, the stream falls at about the same rate for a short distance and then the grade is not so steep, since where it crosses the road between sections 10 and 11 the creek bed is at 1,706 feet.

On the stream which traverses the south-east corner of Section 12 no exposures were seen, but from the elevations, the four-foot seam might be expected near the centre of Section 2. The ground behind Mr. Proudfoot's house is at 1,758 feet.

Northward, the next exposures of coal of this horizon are on section 25, where a deep ravine cuts through the edge of the terrace at a point where it is at about its highest. At Mr. Powne's house on the edge of the ravine, a well was bored for 127 feet and passed through coal or

Sec. 25.

*Several holes are noted by Dr. Selwyn just north of the Vaden mine and in one not far distant a seam of 7 feet was struck at 30 feet from the surface.

coaly matter at about 102 feet. The curb of the well is at 1,853 feet and this brings the horizon of the coal at about 1,751 feet. To test this, Mr. Sherman, of Deloraine, put down a pit in the bottom of the ravine at or near the point where it forks. The elevation of the spot selected is 1,760 feet and the coal was struck at 8 feet, eqnivalent to 1,752 feet. Little information could be obtained as to the thickness found, but it may probably be assumed to be the same seam as the one at this elevation at the Vaden mine. A bore-hole was also put down, but the depth is unknown. The bed of the ravine slopes rapidly to the west and at the centre of the Section, or in a distance of about a quarter of a mile from the forks, the fall is 15 feet—enough to bring the bed of the stream below the coal seam, and it is very likely that a tunnel at this point into the bank would strike whatever coal there is. The section in the well shows a depth of about 25 feet of sand and sandstone above the coal with clay and sand higher up. A well north of the stable and upon the north slope, was bored from an elevation of 1,825 feet down to 1,760 in the sandstone, where water was obtained but without reaching the coal seam.

Sec. 36. Following this terrace northward to Section 36, a well at Mr. Morningstar's in a slight ravine in front of the house, passed though a small seam of coal and ended at a depth of 17 feet in another. The elevation at the well curb is 1,774 feet and at the coal about 1,756, or slightly higher than those determined south of this. A well subsequently bored from the top of the bank showed the thickness of the seam to be only 22 inches. The same seam was also struck by Mr. Poole, who lives on the north-east quarter of the same Section, in a well near his house. These borings seem to indicate that the coal of this horizon thins out considerably in going north, bnt this may be only a local feature.

Sec. 26. A lower horizon for coal is probably indicated by the presence of springs on Section 26 at about the 1,700 feet mark, though the boring at the Vaden mine showed nothing there as far down as that level. Along the eastern edge of Section 26 there are three small ravines with springs in each. The one near Mr. C. Corbett's house is about 30 feet deep and at an elevation of 1,700 feet a shallow well was dug through soil in which loose pieces of coal were found. The fact that the coal seams nearly always produce water would incline one to think that either coal or a very permeable layer of sandstone was situated beneath the tough clay which is reported as being bored through in another well near that at the house. Two miles south of this, on the north-
Sec. 14. west quarter of Section 14, Mr. Hughes reports loose coal in a well

dug in a low spot east of the house. This is on nearly the same elevation as the Corbett spring.

No other reported occurrences of coal were heard of to the west of this, and the wells in the vicinity of Goodland all seem to reach the gray shale below, which is probably Cretaceous, and the intervening sandy clays and shales which form the material between the elevation of 1,650 feet in Goodland and the foot of the slope at the 1,700 feet contour probably represent the Fox Hill sandstones.

North-eastward, the horizon at which the coal seams are supposed to occur does not appear to have been prospected or rather the bore-holes for wells have not been put down deep enough, so that very little information could be gathered. One exposure on the roadside in a shallow cutting at the north west corner of Sec. 8, Tp. 2, R. 23, shows a thin seam of lignite at 1,734 feet elevation. This is probably the same seam as the lowest streak of coal in Mr. Morningstar's well at 1,740 and the 1½ ft. seam in the flowing well at Vaden at 1,732. Tp. 8, R. 23. Sec. 8.

A long ravine running from the mountain in Sec. 1, Tp. 2, R. 23, passing through Sections 11, 14 and 15, is cut down through about forty feet of the rocks, but the exposures along the sides are concealed by surface deposits. A small exposure of sandstone can, however, be found on Section 15. The coal seams evidently should crop out on the sides of this ravine, as they have been found by boring in the centre of Section 11 at the bottom of the ravine near Mr. Duncan McArthur's house. Here three seams were found with thin clay partings and the two upper ones are thick enough to work. Subsequently a shaft was sunk from higher ground and for several years a small quantity of coal was taken out during the winter months. Long ravine. McArthur's mine.

The section obtained by Dr. Selwyn, as published in the Summary Report for 1892, is given below. * 'On the north-west quarter of this Section, the owner, Mr. Duncan McArthur, has sunk several shallow pits, and a shaft 23 feet deep in which he states three seams of lignite coal were found with intervening clay strata.

	Feet.	Inches.
First seam at seventeen feet....................	2	6
Second seam at	2	6
Third seam at twenty-three feet, thickness not ascertained.		

All the workings were full of water at the date of my visit. From the specimens of the lignite shown me by Mr. McArthur, it appears to be of similar quality to that now being mined at Estevan, and would

*Summary Report, Geol. Surv. Can., 1892, p. 4A.

certainly be a valuable fuel for local use if mined and sold at a reasonable figure.'

Sec. 11.

It is now about three years since this mine was operated, and as Mr. McArthur was absent, additional information as to the nature of the workings was hard to obtain. From Mr. R. W. Weaver of Deloraine, who had worked in the mine, I learned that the clay partings were not of great thickness, generally about 18 inches, but that sometimes the upper one disappeared or was replaced by coal and then the seam reached a thickness of six feet. The lower seam was not worked.

From my levellings, the elevation of the ground at the pit is at about 1,825 feet. This would place the top of the upper seam at 1,808 feet and the bottom of the second seam at 1,802 feet. The seam slopes, according to Mr. Weaver, slightly to the north. This fall must be slight, as at the next point where the seams have been bored into, at Mr. Smith's on the south-west part of Section 24 in the same township, the elevation of the top of the coal is at 1,783 feet. This is about a mile and a half north and half a mile east of McArthur's, and shows a fall in that distance of 25 feet. Mr. Smith, in digging a well near his house, struck the coal at 24 feet and dug into it three feet. He then stoned up the well but afterward was induced to try and ascertain the total thickness. His efforts in reaching the base in the narrowed diameter of the well enabled him to get down about four feet, so that he has hopes that the seam is seven feet in thickness.

Sec. 24.

Smith's 7 ft. seam.

Probable outcrop.

These estimates may be over, rather than under the actual amount and it would seem, that here the two seams that occasionally form a six feet seam in the McArthur mine are brought together again. If there is over that amount here the seam should be worked, as fuel in the district is getting scarce and there is a large local market. The ravine leading north from McActhur's should afford good points for the mining of this seam without the necessity of raising and pumping by steam or other power. The slope in the ravine north is quite steep and the fall from the mine to where the road between Sections 14 and 15 crosses it is 57 feet, and 45 feet below the ground at Smith's house or well. It would thus seem that the lignite should outcrop in the ravine on Section 14 and along the sides on Section 15. At Smith's the coal can be got at from the level by a long open-cut from the north, as the ground slopes to the north and a point at the centre of the farm in a ravine which heads in two branches on either side of the house is 25 feet below the top of the coal.

Urie's well.

On the eastern part of this Section Mr. Urie has dug a well 50 feet deep without reaching the coal, but as the elevation at his house is

about 1,830 feet his well, at the bottom is very close to its probable position.* In the next township to the east very little was heard of any discoveries of coal, but there is one point of interest in connection with the possible future discovery of seams of workable thickness in the existence of a deep ravine crossing the western tier of sections, convenient points from which to work should be found there. From the levellings at Smith's and across the ravine on Section 19, Township 2, Range 22, it would seem that if the level of the seam continued to the east at nearly the same elevation, the outcrop would reach this ravine north of the centre of Section 19 and be found by drifting along the slopes as far up the valley as the road crossing at the south side of the same section. Mr. Renton who owns the section and lives on the south-west corner of Section 20, has bored a well at the top of the bank near his house and by this has proven that there is no coal down to within a few feet of the 1,800 feet elevation. He has also sunk a well in the bottom of the ravine from about 1,788 feet and finds there loose pieces of coal. The question of the coal existing between these two elevations has therefore not been tested. Renton's section.

Eastward, in the next township, little could be learned of any discoveries of coal, but the lines of equal elevation follow a direction about E.N.E., and the probability of finding any would be greatest in Sections 19 to 24, although on Section 25, belonging to Mr. Shepard, loose coal is reported in a well in the bed of a ravine on the northern part. Higher up the slope, there are, unfortunately, but few bore-holes, and the only discovery reported is of a seam a few inches in thickness on Section 4, owned by Mr. G. Rickard. In the mountain on Section 24, Tp. 1, R. 22, at an elevation of about 2,200 feet, Mr. H. Russell found a small mass of loose fragments of poor lignite in a small well near his house. This may have come from the drift, as this part of the mountain is thickly covered by boulder clay and there seems little evidence that exposures of the underlying rocks would be found in a shallow well. Tp. 2, R. 22.

On the road south from Boissevain, sections of the underlying strata are seen on the road cuttings and in a series of quarries to the south of the town. On the road passing along the eastern boundary of the township and at a point south-east of the town, sandstone of a soft character is obtained on the north front of the steep incline, and also in a deep ravine crossing the road. On the road a mile west, running south from the western edge of the town, dark yellow sand is exposed at the top of the hill in the road cutting at an elevation of 1,729 feet. South of Boissevain.

* In Dr. Selwyn's note-book for 1884, it is learned that Mr. Urie, west of Deloraine (Old Deloraine), cut 3 feet of coal in a well. What section this is on can only be conjectured as it is possible it is the Smith location.

Sandstone quarries.

A harder layer, and probably the same bed as that quarried in the hill a mile east, is exposed in the banks of a creek running through Sections 11 and 14 and stone for several fine buildings in Boissevain has been taken from a quarry on the south-west part of Section 11 or the adjoining part of Section 10. The upper part of the exposures along the creek are of dark yellow sand with a few reddish streaks from ironstone. This is also exposed in a ravine on the north part of Tp. 2, R. 19, and is mentioned by Dr. Selwyn in Report of Progress for 1879-80, p. 11A.

Below these sands at the quarry is a lighter coarse-grained sand in false beds and irregular layers not apparently hard enough for building purposes, but below this is a dark gray sandstone, the cracks and crevices in which are stained dark with iron rust. This stone is probably near the base of the series and may represent the Fox Hill sandstone at the base of the lignite Tertiary. This would consequently be the northern limit of the coal-bearing rocks of this area.

Shales north of mountain.

In the lower ground on which the town is situated wells that have been bored reach the shale which underlies all the country to the east and north as far as the edge of the Pembina mountain. The well bored on Section 19, five miles west of Boissevain, did not reach the shale, though 75 feet of drift were penetrated. A boring on Section 34 north-west of the town went through 63 feet of clay, 4 feet of sand and 103 feet of shale, and the well bored in Section 23, just west of the town, gives a section of 64 feet of clay and hard-pan and 198 feet of shale. This shows that the shale is the underlying rock up to the foot of the hill south of the town. The sandstone probably skirts the edge of the hill westward, and occasional outliers occur even as far west as Waskada in thin sheets and are pierced by wells. South of the quarry traces of coal have been found at several different horizons.

Tp. 2, R. 20.

The lowest coal heard of is in a well on the north-east quarter of Section 35, Tp. 2, R. 20. There were three inches of very poor lignite at a depth of 12 feet from the surface. The elevation above sea of this coal is 1,772 feet. The next is on the south-west quarter of Section 24, same township, where Robert Johnston found four feet of lignite in a shallow well dug in a depression draining north, near the western boundary of the section. The well is dug through eight feet of sand and clay and then through a four-feet seam of the coal. As it was full of water at the time of my visit the character of the seam could not be examined. The surface of the ground at the well slopes gently to the north, and though the seam is not far from the surface it would have to be worked by a shaft and unwatered possibly by a long drain or open ditch running from near the north boundary of the section.

Johnston's 4 ft. seam.

On the south-east quarter of Section 13, Mr. J. Dalrymple had a well bored in which the seam was reached at a depth of 25 feet, but the thickness did not seem to be as great as on the Johnston property. Samples of the coal which had been kept for over a year showed bright fractures and a good quality of lignite. The elevation of the seam is approximately 1,845 feet and at the former place between 1,836 and 1,832 feet. On Section 12, just to the south, Mr. Glover, who owns the east half, found coal in his well on the edge of a ravine which runs north-east across the section. At a depth of fifteen feet a two feet seam was passed and after boring through six feet of clay another seam was reached in which a supply of water was obtained. The thickness of this was not ascertained. As the ravine is twenty-eight feet below the well-curb these seams could be worked from the level very cheaply, even though there is not a great thickness of coal. The two-feet seam in Glover's well is at 1,898 feet and the top of the lower seam at 1,892. Glover's well.

A quarter of a mile up the ravine Mr. A. M. Ross also reached coal in a well at a depth of about forty feet. As the elevation of the ground is above that at Glover's, the same seams would probably be reached between forty and fifty feet below the surface. Other reported instances of finding coal in wells in this vicinity are on Sections 14 and 15, where Wm. Hall and Mr. Wilson both report reaching a seam at about 25 feet, probably the same one as the Johnston seam. Ross' well.

At Lake Max in the mountain at an elevation of about 2,200 feet, Mr. Cox, who lives on Section 31, Tp. 1, R. 20, dug a well for Mr. Kasper Killer on one of the islands, and at a depth of 27 feet found coal. This was not dug through but it tends to show that there is a possibility of there being several horizons above that outlined on the lower part of the slope of the mountain in which the lignite may yet be found in paying quantities. Lake Max.

Few reports of coal could be obtained from residents of the townships to the east. Many farms having changed hands within the last few years after the wells had been dug, the present owners have no knowledge of the strata passed through. On Section 27, Township 1, Range 18, a well is reported as having been bored through a coal seam, but the present owner could give no definite statement to that effect. On Section 15 in the same township, shale of a light gray colour is exposed in the garden at Mr. Mitchell's house, and also in a shallow well in the bed of a small creek south of the house. There is no direct evidence of the presence of any coal, but it would seem to show that in places the surface covering is thin. On Section 12 an old resident Tp. 1, R. 18.

reported that coal had been found some years ago in a well, but the present occupier of the lot, Mr. Reedman, could not corroborate the statement. A new well at his house was dug through forty feet of sand and clay with no coal. Mr. E. C. Skinner on Section 18, Township 2, Range 17, found a small seam at 28 feet below the surface which he thought was about one foot in thickness. The elevation of this seam is approximately at 1,824 feet above the sea.

Bore-hole by Dr. Selwyn.

The Turtle mountain bore-hole which was sunk by Dr. Selwyn in 1880, is referred to in the report for 1879-80, p. 10A, and by a misprint its location is wrongly stated. Its situation is on the south-east quarter of Section 5, Township 2, Range 19, and is at the mouth of a small ravine just at the edge of the woods. The location seems to have been unfortunate, as apparently there was a previous depression filled in with boulder clay and sands and gravel. The bore was carried to a depth of 200 feet without any seams being found. As the elevation of the ground there is about 1,955 feet, it seems remarkable that no trace of the seams which are known to occur at 1,835 and 1,890 feet, a short distance to the west should have been noticed.

Many occurrences have no doubt been missed in this hurried examination and more complete information might have been obtained had we means to test by bore-holes both along the outcrop and up the slope of the mountain.* In this manner a section of the mountain could be made. As it was, much of the time was taken in making a contoured plan on which to base future work.

The result of the series of levellings shows that though the coal seams are approximately horizontal, still there is a general slope to the westward of slight amount as well as a local bending to the north along the north slope of the hill.

Formation of coal.

The coal horizon does not appear to consist of a series of seams in continuous sheets but rather of deposits which are limited in extent though repeated over large areas and often superposed without the intervention of much sand or clay. A thick seam may thus be represented in an adjoining locality by a series of thin seams separated by sheets of sand or clay. The material from which the coal was derived seems in many instances to have been made up of a large percentage of woody matter, but a great part is probably composed of much smaller plant remains similar in character to much of that in our present swamps and peat bogs, though of different species, such as would be

* Dr. Selwyn records a sample of coal from a well on Highman's location, Section 34, Township 1, Range 19.

found in a warmer climate. The shales above the coal in the Souris coal-field (a continuation of these deposits) contain, along with a variety of tree leaves, the remains and impressions of many grasses.

The clays and sands, which are contemporaneous with the coal seams, contain fresh-water shells, so that the ordinary land conditions prevailed only at intervals and the vegetation which sprang up became concealed by deposits which were drifted over them by the invasion of fresh or brackish water. Repeated changes of this nature enabled the accumulations of similar material to be so piled one above the other that with a lapse of time the vegetable matter became so consolidated that its composition approached that of the older coals.

A Geological Reconnaissance about the Head-waters of the Albany River.

Dr. Alfred W. G. Wilson.

Your instructions of date May 24th, 1902, advised me that, in company with Mr. J. F. E. Johnston, C.E., of the Survey staff, I was to undertake a geological reconnaissance of a portion of the southern part of Keewatin district, lying to the east of the area explored by Mr. D. B. Dowling, B.Ap. Sc., in 1893. Mr. Johnston was delayed a few days at the office preparing plans for the season's work, but was able to meet me at Owen Sound on June 7th. We reached Port Arthur on June 9th, where I purchased the bulk of our supplies and one large canoe. Leaving Port Arthur on June 10th we stopped off at Ignace to procure a canoe belonging to the department which had been left there by Mr. McInnes at the close of last season. We found that this canoe had been used by the man in whose care it was left and that it was not immediately available, being out at Sturgeon lake. I wired to Port Arthur for another canoe to be forwarded to Dinorwic, where we intended to leave the railway. We reached Dinorwic on June 11th, and were delayed there until the 14th, partly on account of the unsettled condition of the weather, and partly because we had to wait for the second canoe to reach us from Port Arthur. **Instructions.**

At Dinorwic we procured the balance of our supplies and engaged a crew of four men, three of whom had, the summer before, been over a considerable portion of the country we expected to explore. Leaving Dinorwic on the 14th of June, we were delayed by unfavourable weather and did not reach Lac Seul Post until the 19th. Here we were again delayed some days, partly by unsettled weather and partly because at the time of our arrival the men were away with the York **Delays.**

boats and we could not at first find a guide who knew the Wenassaga route which my letter of instructions directed us to survey through to Cat river. Having engaged a guide, we left the post on the morning of June 23rd and reached the mouth of the Wenassaga river, a mile or two east of the outlet of Lac Seul, on the morning of June 29th.

Method of survey.

We had previously arranged that Mr. Johnston was to take charge of the topographic work, and that I was to attend to the geology, assisting Mr. Johnston where necessary by local surveys off the main line. Mr. Johnston began a log and compass survey of the route from the narrows of Lac Seul, running about eighty-five miles of line, to Slate lake on the Wenassaga, reaching there on July 2nd. On this date the Ashton Kay patent log he was using was accidentally injured, and he decided to run the line by micrometer telescope and compass as far as Gull lake. Continuing from here, surveys were made of seven lakes, varying in size up to about six miles in length. In most cases the shore lines were very complex, with many deep narrow-mouthed bays running off from the main lake, an incidental feature of the lakes of the Laurentian upland almost anywhere.

Gull lake

The height-of-land portage, half a mile in length, and longer than any of the 23 other portages between here and Lac Seul, was crossed on July 15th, and the survey of Big Portage lake, on the Cat river system, begun. The survey of this lake was finished on the 17th and on the 18th we crossed the short portage to the most western bay of Gull lake. Gull lake proved to be very large, with numerous deep bays, and our time until July 30th was employed in the survey of the portions of this lake which lay on the direct route, Mr. Johnston's survey being tied to Mr. Fawcett's line at the portage out of the south-eastern part of Gull lake—Smooth Rock lake of Mr. Fawcett's plan. As a considerable portion of our limited time had now been spent, we were compelled to leave several large bays of Gull lake, off the main route, unsurveyed. On July 30th we started for the Hudson's Bay Company's post on Cat lake, as from the account we had heard, we judged that the balance of our time would be required for the survey of this lake. The post was reached on the evening of July 31st, and on August 1st the survey of the lake was commenced. The work was continually interrupted by bad weather, and the survey of the shore of the lake, and of the adjacent islands, occupied us until the 19th. As Mr. Johnston

Cat lake.

did not consider that the remainder of the time at our disposal was sufficient to complete the survey of the islands in the main portion of the lake, and as it was obviously too short to continue the line as far as the height of land towards Severn lake, I decided to return *via*

the Cat river route to the east end of Lac Seul, and to attempt to locate the southern boundary of the belt of so-called Huronian rocks which outcrop further east on Lake St. Joseph, or Osnaburgh lake. In descending the Cat river I made brief geological notes *en route*. We reached the mouth of a small creek entering Lac Seul from the northwest on August 26th. This creek flows through a rough country burned over about six years ago, and all its portages had to be cut out as we ascended. On August 28th we reached the limit of canoe navigation, the upper part of the stream being very shallow and blocked with timber, and started on our return trip, reaching Lac Seul next day. We returned directly to Dinorwic, arriving there on the evening of Sept. 2nd. Lac Seul route.

During the season we experienced much stormy weather with frequent thunderstorms, causing numerous interruptions of the instrumental work. The total of these delays in intervals of from one hour to a day and a half, caused a loss of about seventeen days in all. Towards the end of July and in the early part of August our work was materially retarded by some difficulties with our men, who were very much afraid of entering the country in the vicinity of Cat lake on account of current rumours respecting the dangerous character of the Indians of that region.

TOPOGRAPHY.

Topographically, the region through which our exploration line passed is a portion of the great uplifted modified peneplain of the Archæan rocks of central Canada. Throughout this portion of southern Keewatin, the various water-bodies lie in shallow basins in the peneplain surface. The maximum relief in the interior, except in the case of a few monadnocks, is rarely over fifty feet; near the southern boundary of the district, the relief is somewhat greater. In a few places, ridges or isolated more or less dome-shaped masses, rise above the general level of the peneplain. One of the most striking of these lies to the west of Cat lake and has an elevation above lake-level of about ninety-five feet. Character of country.

The lakes are shallow, marshy, very irregular in outline, and at times more or less bounded by areas of muskeg (marsh). The inter-stream areas are bare, rounded or undulating surfaces of rock, frequently clothed, especially in the hollows, with a thin drift cover of sandy soil and boulders, overgrown and concealed by a dense mat of moss (generally *Hypnum triquetrum*) and interlaced roots. As a rule the drainage is very imperfect. Occasionally there are small areas, underlain by a thicker cover of drift or by a glacial sand plain, where the drainage is better and the moss cover is absent.

GEOLOGY.

Rock formation.

The rocks of the area may all be classed as Archæan. For the most part they are acid, igneous or metamorphic rocks, generally some variety of either granite or gneiss of some light shade of gray or pink. Associated with these, are several belts of dark-coloured, generally almost black, basic rocks, usually micaceous schists, less often hornblendic or chloritic, which are similar to those which have elsewhere been tentatively classed as Huronian. In general features, they closely resemble the rocks in the vicinity of the Lake of the Woods, classed by Lawson as "Keewatin"*. The broadest belt of these rocks was crossed by our line about 38 miles (by water) above Lac Seul, and it extends in the direction of the line for a distance of about 20 miles. The precise width of the belt cannot be determined until the survey is plotted. Slate lake, around which the best exposuree are found, runs in a direction nearly parallel to the strike. The western extension of this belt is represented on Mr. Dowling's map of the 'Vicinity of Red Lake and part of Berens River,' and described by him in his report on that district.†

Three belts of Huronian.

A second narrow belt is crossed at the height-of-land portage leading into Big Portage lake from the waters tributary to the Wenassaga. The belt is narrow, probably not over a quarter of a mile in width, and exposures are few, at least near the portage. A third narrow belt (hornblende schists) is cut across by the narrow channel connecting the two western parts of Gull lake. In the vicinity of Cat Lake these basic rocks are known to occur only in a few localities, as small inclusions within the granites. Near the belts of basic rocks, it was found that there were generally numerous inclusions of the schists in the associated acid rocks in the areas on both sides of the main belt. At Cat lake a number of these inclusions are found, and there are also in places many drift blocks of similar material, so that it is quite probable that another belt of these basic rocks lies to the north-east of the lake.

Descending the Cat river, a narrow belt of the basic rocks outcrops a short distance above Cross lake. Several other similar bands of the same rocks occur between here and Lake St. Joseph, particularly in the vicinity of Black Stone lake. A wide belt of these rocks, already referred to by Dr. Bell in early reports of the Survey, occurs at the south-west end of Lake St. Joseph. This belt extends towards the west and it is not impossible that the broad belt exposed in the vicinity

* Annual Report Geol. Surv. Can., vol. I, (N.S.) 1885, part CC, page 10.
† Annual Report Geol. Surv. Can., vol. VII, (N.S.) 1894, part F.

of Slate lake may represent its westward extension. The other narrower bands along the Wenassaga seem to have their counterparts along the Cat river. It seems improbable that they extend as continuous bands between the two localities.

ECONOMIC GEOLOGY.

In almost all cases these basic bands are found to contain small (more rarely large) veins of quartz. In some few cases there is a small amount of pyrite in the schists near the quartz veins. At the surface, these veins and the associated schists present the usual rusty appearance due to the decomposition of the pyrite. In most cases the veins seen were small, and it is improbable that (with one or two exceptions) they carry anything of value. A prospecting party working in the district during the summer has located a number of prospects along the Cat river. Whether they have discovered anything of value is not at present known. Pyrites.

The granites are occasionally cut by pegmetite dykes. In one locality near the head of Cross lake, a rock, apparently of this character, carries a small amount of molybdenite in crystals varying up to about an inch and a half across. Whether the mineral occurs in sufficient quantity to be of economic importance has not yet been determined. The property is at present in the hands of Mr. C.W. Ross, of Dinorwic, to whom the writer is indebted for specimens of the mineral. Molybdenite.

Near the inlet into Slate lake, about three-quarters of a mile from its north-east end, on the eastern shore, Mr. Johnston noted in the schists small stringers of a metallic mineral, probably magnetite, as the local variation of the compass was considerable. Magnetite in small amount is a constituent of many of the basic rocks. This was, however, the only locality where it was found sufficiently segregated to produce a noticeable local variation of the compass. No occurrence of hematite ores was noted. Magnetite.

TIMBER.

The timber throughout the areas where our explorations lay is small; in most parts of the district apparently too small for use even for pulpwood or ties. The general aspect of the forest and the age of the various kinds of trees indicate that forest fires have swept over the region at intervals. On the islands, or in localities otherwise protected, one frequently finds fairly large trees, so that there is no reason to think that the small size of the forest trees is to be attributed to the character of the climate. Timber.

GAME.

Game.

Large game is fairly plentiful in the southern parts of the district, but in the central portions and around Cat lake it seems to be scarce. Game birds, except water fowl, are not plentiful. The region around Cat lake is a breeding ground of the mallard duck. The common fur-bearing animals of our northern districts are found here, though no species is very abundant, and some, particularly the beaver, are scarce. So far as could be ascertained, no brook trout occur in any of the streams; whitefish and sturgeon are taken in some of the larger lakes; pike are found in all the waters.

I wish, in conclusion, to acknowledge our indebetedness to the officers of the Hudson's Bay Company in charge of the posts at Dinorwic, Lac Seul and Cat lake, for many courtesies, particularly for the assistance rendered in procuring suitable men, and in storing supplies and outfit.

REGION ON THE NORTH-WEST SIDE OF LAKE NIPIGON.

Mr. William McInnes, B.A.

Assistant.

I left Ottawa on the 3rd of June, accompanied by Mr. E. A. Small, of Montreal, who had been appointed as field assistant for the summer. Mr. Small remained in the field until August 21st, when he was allowed to return in order to take up his work at McGill University.

After buying canoes and provisions, Nipigon station was left on the 8th of June, and Lake Nipigon reached on the 12th.

Starting point of survey.

According to instructions, the work of the summer was to be carried on in the country lying to the west and north of the upper part of Lake Nipigon, with the object of gathering the data, both topographical and geological, necessary for the completion of the forthcoming map of Lake Nipigon and the surrounding country, and of exploring the district lying to the east of that reached last year from Sturgeon lake.

Trap hills.

After being detained by heavy winds for two days, Nipigon House was reached on the 16th, and an examination of the shores made, up to the mouth of the Wabinosh river. A micrometer telescope survey was started from the mouth of the Kobka river (the south branch of the Wabinosh). The river, which was found to be at a very high

stage, shows here and there cut banks of a white, silicious sand, which fills the bottom of the narrow valley between the high trap hills through which the river runs.

Jegemassin and Kobka lakes, successive expansions of the river, are surrounded by high hills of trap, rising three hundred feet above their level. From Kobka lake a portage leads over a high hill rising 200 feet above it to Obowanga, the principal lake on the river. Extending south-east and south-west, it has a length of thirteen miles, and varies in width from half a mile to a mile. Everywhere along the lake the prevailing trap hills occur, though on the north shore these are some miles back from the water, the intervening flat land being occupied by an area of sand and gravel at a level of about fifteen feet above the lake. The main river falls into this sheet of water at its north-east corner. After surveying Obowanga lake, a stream entering its extreme western end was followed almost directly westwards. Leaving Obowanga, the underlying felspathic schists of the Huronian are exposed, striking about east and standing almost vertical. The stream followed proved to be a series of long narrow lakes connected by rapids and falls, the levels rising rapidly until, at about thirty miles from Lake Nipigon, a height of 1,350 feet above sea-level is reached, with neighbouring hills rising 200 to 300 feet higher. The north-west edge of the Huronian belt is here reached, the general trend of the contact being about north-east. No travelled route extends up this stream, so that it was necessary to cut out portages from lake to lake, most of them over very rough ground.

North-west limit of Huronian belt.

Returning to Obowanga lake, another route was followed from its south-west bay to Otter lake and thence westerly. Otter lake occupies a long narrow valley hardly wider than the lake itself, with high hills of Huronian schist rising on the north side 200 to 300 feet above its surface, and on the south side nearly 500 feet. The main inlet of Otter lake comes in from the south at the head of the lake, discharging through a gorge so narrow that, excepting at extreme high water, the stream makes its way underneath the piled up debris of angular blocks fallen from the cliffs on the sides. The stream occupies a narrow valley with a high cliff facing it on the west side, and still higher hills rising sharply on the east.

Otter lake.

Leaving Otter lake, a portage two miles long climbs in a steep slope up the almost vertical side of the valley, reaching a height of over 300 feet above the lake and descending again 100 feet to a smaller lake from which a portage three-quarters of a mile long leads to one of the head-waters of Gull river. Huronian schists occur all along, preserving

Route westerly from Otter lake.

a generally regular strike N. 70° E. and dipping nearly vertically. This branch of Gull river was followed westerly for about six miles, where its course changes somewhat sharply and it splits into two branches coming from the south.

Head waters of Albany river.

A series of lakes, flowing into this branch from the west, was followed and a divide crossed to lakes emptying northerly. Similar schists of the Huronian occur all along with the same general strike and dip and give place, at the head of this series of lakes, or 37 miles west of Lake Nipigon, to biotite granite-gneisses, which continued westward beyond Shishibak lake, the most westerly point reached. The country seen from this lake on every side, is comparatively flat, no hills rising more than fifty feet above the general level which reaches 1,600 feet, or thereabouts, above the sea. The forest growth is generally small, owing probably to the thin covering of soil; it is everywhere green and no general fire has burned over this area for a great number of years.

Obowanga lake to Gull river.

Returning to Obowanga lake, a route was surveyed from its south-west bay across to Gull river and thence down the river to Lake Nipigon. The southern edge of the Huronian belt above referred to lies about a mile to the south of Obowanga, where it is in contact with the granite-gneisses that continue to the south and is overlain by the traps of the Nipigon series on the east. The width of the belt of Huronian thus defined is about eight miles, measured where it disappears under the trap capping.

Gull river.

From the point where the Gull river was reached, to its mouth, it is a deep, smooth-flowing stream, broken in this distance (about 18 miles) by only three short rapids. It has a fairly uniform and strong current and has cut its channel to a depth of from ten to thirty feet in the drift deposits of the valley.

North branch of Wabinosh.

For the purpose of further exploring the area under consideration, the north branch of the Wabinosh river was then followed nearly to the height of land, and a series of lakes and streams lying further to the west was surveyed by micrometer telescope. These lakes and streams included a number that flow northerly by way of Smooth rock and Island lakes and the Okoki river into the Albany river. Among them Shawanabis has a length, east and west, of about sixteen miles with a long arm extending southerly at its western end.

Character of rock exposures.

The traps of the Nipigon series are the only rocks seen all the way up the north branch, with the exception of two isolated areas of gneiss occuring at Waweig and Washebimega lakes, where they are exposed by

the denudation of the overlying beds. The edge of the main area of the traps, where they overlie the gneisses, is reached at about three miles west of the north branch, beyond which only granite-gneisses occur.

Waterfalls.

Leaving Shawanabis, a route was taken leading southerly through smaller lakes to the Kopka river, flowing into the east end of Obowanga lake. This is a river of fair size, the largest of the Wabinosh streams, that has not yet appeared upon published maps. Along its course occur a series of lakes, the principal of which are Kenakskanias five miles long, Wigwasaus six miles long, and Bukemiga eight miles long. Between Kenakskanias and Wigwasaus, in a distance of a little over a mile, the river descends 250 feet in a series of rapids and cascades.

At the foot of this drop the edge of the Nipigon series is seen, flat-lying beds of white and red siliceous sandstone protruding from beneath a thick covering of trap. From this point eastwards to Lake Nipigon the traps are continuous excepting where, in some of the valleys, denudation has exposed the underlying rocks in limited areas. These are elsewhere more particularly noted.

White Sand river.

The White Sand river, which empties into Lake Nipigon on its western side two miles and a half south of Mount St. John, was then ascended and the lakes along its course examined. The river and its lakes lie in an extensive, rolling, sand plain, underlaid by granite-gneisses.

Through this overlying sand the river has cut to depths reaching in places 100 feet, and cut banks of sand of that height occur along its lower stretches.

Sand plain.

The white siliceous sand covers an area many miles in extent. The surface of the plain is gently rolling, its generally level character modified only by occasional low ridges and by the valleys cut in it by streams. The tops of the ridges are generally quite bare of vegetation, the loose sand, readily drifted by the wind, affording no hold even for the mosses that cover it in more protected places. The side of the ridges and the valleys support a limited growth of coniferous trees of small size.

Pikitigushi river.

The Pikitigushi river, flowing into Wendigo bay, was then examined. From the mouth up to Round lake its course is winding in the extreme and few exposures of the underlying rock are seen, the banks being made up of sand. Cliffs of trap are, however, seen here and there at

no great distance from the river. At the north end of Round lake a belt of Huronian schists and diorites form the hills back from the shore. Continuing up the river, its valley is found to have been cut down, through the overlying traps into the Huronian schists and granite-gneisses, the inclosing hills still showing cliffs of the overlying trap. The same conditions extend across the height of land and down northwards to the Okoki river, where the edge of the trap overflow is reached and where the granite-gneisses are seen, immediately underlying the traps, the latter cutting the gneisses in dykes, arms and irregular masses. To the northward of the edge of the main area smaller isolated areas of trap are here and there seen, generally in the form of conical hills, showing that the trap once extended for some distance to the north of its present limit.

Height of land.

Outliers of trap.

Excluding recent drift deposits, there are represented in the area under review, only the granite-gneisses and crystalline schists and associated rocks of the Laurentian and Huronian and the uncomformably overlying sedimentary series of sandstones, limestones, etc., known as the Keweenawan or Nipigon series. All of these are cut and overlain by a later basic intrusive that varies from a fine diorite to a coarse gabbro.

Topography.

This sheet of trap gives to the whole basin occupied by it a highly indented topography, characterized by high, comparatively flat table lands, intersected by deep narrow valleys. The sandstones and limestones are seen at but few places, at the base of cliffs of trap that overlie them and at the edge of the basin where they protrude from underneath the trap. Outliers are seen in a few places lying on the old rocks at some distance from the confines of the main area, but for the most part they have been entirely denuded where unprotected by the capping of more resistent rocks.

Dykes.

Where the underlying gneisses are exposed near the edges of the trap-covered area both on the west and north they are cut by numerous dykes of the intrusive rock, long apophyses extending off in places far into the gneisses forming ridges that by their black colour are in sharp contrast with the invaded gneisses. This dissimilarity has induced some prospectors to locate claims presumably for iron, or perhaps for general results, along these arms.

Economic minerals.

No minerals of economic importance have been found in the district, though the belts of Huronian schists to the north and west of the lake make the occurrence of gold and iron not improbable, Iron ore, in the form of float, has been found at several points, but its source up to the present is not known. A deposit of iron pyrites of considerable

extent occurs on the Pikitigushi river. Some of the siliceous sandstones, which vary in tint from white to pinkish red, are of very even grain and would make good building stones were a demand for these ever to arise.*

Agricultural land.

Lands suitable for agriculture are confined mainly to the immediate shores of Lake Nipigon and to the valleys of the larger rivers and lakes. At Nipigon House the ordinary varieties of garden vegetables succeed very well; clover and various grasses grow luxuriantly, and oats sown late grew very long and strong, but were hardly ripe before the early frosts.

Mammals.

Moose were found to be numerous in the district during the summer; caribou fairly plentiful, and Virginia deer rare. One wolf was seen, and the tracks of others, running singly were observed. Bears, beaver, otter, marten and other fur-bearing animals still occur in good numbers, the unburnt condition of the forest favouring the preservation of the smaller fur-bearing animals.

Fishes.

Many of the streams entering Lake Nipigon abound in speckled trout *(salmo fontinalis)* of large size. In the White-sand river they were particularly plentiful, those caught varying in weight from one pound to three pounds. On the main lake one was taken that scaled six and a half pounds, and the diary at Nipigon House, the Hudson's Bay Company's post on the lake, records the netting of a twelve-pounder. That this was really *salmo fontinalis* there can be no room for doubt as the lake trout and brook trout are well known and clearly distinguished from each other by both the company's officers and the Indians. Whitefish and lake trout are also plentiful in the main lake, and lake trout, pike and doré in most of the smaller lakes.

I left Nipigon House on the 7th of October and reached Ottawa on the 16th of the same month.

Region Lying North-east of Lake Nipigon.

Dr. William Arthur Parks.

Area examined.

I have the honour to submit herein a summary report on the geology, physiography, economic resources, etc., of the region lying north-east of Lake Nipigon in the province of Ontario and constituting the eastern half of map-sheet No. 17 of the northern Ontario series. This sheet comprises an area measuring 72 by 48 miles, of which a considerable part is covered by the waters of Lake Nipigon. The area which I was

*Dr. Bell with several assistants surveyed Lake Nipigon in 1869 and his report of that year describes the geology of its shores.

instructed to explore contains about 1,500 square miles of land surface, roughly defined as follows :—

The territory lying north of a line drawn due east from a point on Lake Nipigon, two miles south of Mungo Park point, a distance of about 25 miles west of a line drawn due north 48 miles from the eastern termination of the above east and west line, and south of a line drawn westward from the northern termination of this meridian, a distance of about 45 miles to the Jackfish river.

Previous work done.

The shore line of Lake Nipigon bordering this region to the westward was examined by Mr. Peter McKellar acting under the instructions of Dr. Robert Bell, in 1869. At a later date, 1892 and 1898, Messrs. Dowling and McInnes made some further and possibly more minute surveys of parts of the shore line and some of the islands. The country inland was, however, practically unexplored, with the exception of the instrumental survey of the Obabika river made by Dr. Bell in 1871, when en route to the Albany river.

Instructions.

Early in June, I received instructions from Dr. Robert Bell, Acting-Director of the Geological Survey of Canada to proceed to this field and to examine as fully as time would permit the various features commonly dealt with in a geological report, as well as to extend our knowledge of the local geography by making track surveys of all water-courses in any way accessible. Special attention was to be given to the economic resources of the region and the condition of the timber throughout the district.

Route followed.

Pursuant to these instructions I left Toronto on June 10th, proceeding by rail and steamboat to Port Arthur where a day was spent purchasing supplies, etc. On June 14th, I proceeded to Nipigon where I met my assistant, Mr. Paul Smith, of Windsor, Ont., and where I secured the services of two canoemen for the summer, as well as an additional man and canoe to assist in transporting the supplies up the river. On the evening of June 18th we camped at the north end of Flat Rock Portage on Lake Nipigon and were forced by a strong north-west wind to remain there the following day, but by paddling all night, we were enabled to reach Poplar Lodge on the morning of June 20th. This point we made our headquarters during the summer, and I was fortunate in exchanging the large cedar canoe with which I had ascended the river for two smaller ones, more suitable for inland work.

Itinerary.

Having paid off one man, we proceeded directly to the Red Paint river, the exploration of which stream and its tributaries occupied us until July 16th, when we regained Lake Nipigon. Finding it neces-

sary to go to Poplar Lodge for supplies I directed Mr. Smith with one man to proceed to the mouth of the Obabika river and await us there, while with the other man I went to Poplar Lodge and thence to the Obabika. Reaching there, I was surprised to find that Mr. Smith and man had not arrived. It appears that they had become lost on the lake and had wandered around for five days before we finally encountered them off Mungo Park Point. Arriving at Poplar Lodge I directed Mr. Smith to remain there until the kindness of the Algoma Commercial Company should afford an opportunity for his transportation down the river. From this time on, the work was continued with two men and one canoe. During the search for the missing men, I succeeded in working out the geology of the shore line between the Red Paint and Obabika rivers. On July 26th we started the ascent of the latter river and carried a traverse to the border of the sheet. Several overland expeditions were made and two connections established with previous excursions from the Red Paint. A winter road north of the river gave access to the lake at the head waters of the Kabasashkandagogama river, thus extending the section north and south a considerable distance. The more westerly section was brought to the northern boundary of the sheet by the northward tendency of the river from Summit lake on the Obabika. The work on this river was finished by August 10th. Thinking it advisable to examine the eastern extension of the South Obabika trap area, a trip overland was made from the south-east corner of Obabika bay, and to determine the elevation of the trappean hills forming the south peninsula of Obabika, an excursion was made across this strip of land.

Jackpine river.

On August 14th we began the exploration of the country accessible by the Jackpine river which enters Obabika bay from the north. This stream was ascended as far as the border of the sheet and expeditions were made eastward from it. The Jackpine forms part of a canoe route to the Albany and connects with a route via the Obabika. On our return from this trip on August 18th a few days were spent in attempts to ascend the small streams entering Obabika bay from the eastward, but owing to their small size and the burnt character of the country but little return was obtained for the time and energy expended. Finding that the time could be more advantageously spent in the southern part of the sheet, we returned to East bay and ascended to the large lake crossing Beatty's line known as 'Little Long' lake, 'North Wind' lake, &c. From this lake expeditions were run north to the Red Paint river and eastward to the large lake forming the source of the south branch of the Red Paint. Though we failed to reach the big lake the expedition proved of service in fixing the position of the lake called Crooked Green on Mr. Dowling's plan. On August 29th I walked over-

land from the southern point of "Little Long" lake to the Sturgeon river in order to mark the rock contacts and to examine the timber of this region. The Sturgeon river was then ascended to the mouth of a large brook entering from the north about a mile west of the big bend. A traverse was carried up this river in the hope of making a connection with the aforementioned large lake on the Red Paint. We were successful in this as well as in locating some important contacts of rocks I had hoped to find. Poplar Lodge was reached on the return trip on September 7th. A heavy gale prevented our moving until Tuesday the 9th, but having recourse to the expedient of night travelling we arrived at Camp Victoria the next night and reached Nipigon station on the afternoon of September 11th. I paid off the men there and went to Port Arthnr the same evening where the final business connected with the expedition was settled. I reached Toronto on September 14th, having been absent on the survey 94 days.

Sturgeon river.

Duration of trip.

The lines of survey above indicated were all conducted on "track" methods, connections to known points being made where possible, which frequently entailed arduous overland expeditions. Owing to the heavy nature of the travelling but small rock specimens were brought, about 150 of which are now awaiting examination. A daily record was kept of the pressure of the atmosphere and of the temperature of both air and water. The weather during the summer was very wet, thunderstorms and heavy rain being of frequent occurrence. In ten years' experience of northern Ontario I have no hesitation in pronouncing this the wettest season I have spent in the bush. The continual rains had the effect of keeping the poisonous flies in life long past their usual period of activity, both black flies and mosquitoes being in evidence up to the last day we were in camp. The highest temperatures recorded were 78° on July 1st and 79° on August 3rd, and the lowest day temperature 42° at 11 a.m., June 26th. Much lower night temperatures prevailed, ice being formed on several nights in August and September.

Nature of work done.

Temperatures.

PHYSIOGRAPHY.

The region under discussion, omitting certain trappean areas along the shore, consists of a table land not exceeding 400 feet in height, falling with some abruptness into Lake Nipigon. The height of land between the Nipigon waters and those flowing north and east may be said to lie just within the eastern border of the sheet and to be represented by an extensive level swampy tract extending from the vicinity of the 'dam' on the Sturgeon river northward to the boundary of the sheet. This wet area supplies a large brook entering the Sturgeon at

Character of country examined.

the point above referred to. It sinks into a depression occupied by a large lake forming the head-waters of the south branch of the Red Paint river, supplies the drainage at the source of the north branch of this river and is responsible for Summit lake on the Obabika river, the head-water of both that river and a stream flowing north to the Albany river. This level tract is fringed on the west by a more rocky area and, at some points, considerably higher land through which the various rivers break on their way to Lake Nipigon. Evidences of considerable dissection are observable between this fringe of hills and the lake, giving a rough aspect to the country in places and producing a relief of about 400 feet. The general lines of dissection have followed the synclinals of the rock, the axes of which extend in a direction north of east and south of west. Erosion of these lines is facilitated in the Huronian areas by the correspondence of the prevailing strike with this general direction. The region is therefore a dissected tableland with a somewhat abrupt fall to Lake Nipigon and a gradual ascent to the eastward, followed by a minor descent occupied by a wet area constituting the source of a number of rivers. This general structure is, however, modified along the shore by the deposition on the flanks of the plateau of a coarse sandstone, overlaid by a trappean belt of about 300 feet in thickness. This basic rock forms a ridge, interrupted in places, extending along the shore line from the north to the south of the sheet. At its northern end this area is more distinctly ridge-like, while its southern extension attains a much less pronounced elevation and stretches farther inland. This structure is shown in the character of the shore line, for the northern ridge has obstructed the egress of the waters from the east, turning them southward and causing them to hollow out a shallow bay between the edge of the plateau and the range of trappean hills. At a later age an opening was eroded through the ridge so that the waters entering this bay, Obabika (Steep Rock gap) no longer were forced southward but escaped into Lake Nipigon by the means thus afforded. At the southern border of the sheet, the previously described contour is not materially affected by this trappean rock as its elevation is inconsiderable, but on proceeding northward, it becomes more pronounced, forming a promontory of 200 feet elevation at Livingstone point. This point is now an isolated mass as the forces of erosion have worn away the connecting rock both to the north and to the south forming deep bays, called by Dr. Bell, Humboldt and East bay respectively.

Red Paint river.

Nature of surface erosion.

Basic work.

Trap masses.

The Sturgeon river, entering Lake Nipigon just south of our sheet, is the main line of drainage from the east; immediately north of it a rocky hill of 200 to 300 feet rises abruptly to the level of the plateau.

Lines of drainage.

From this region the waters drain south by tumultuous streams into the Sturgeon. On ascending this river the banks are seen to have a lower elevation, and finally, at a point about 20 miles up, we enter the previously described low area, the southern part of which is drained into the Sturgeon by a stream from the north and west. Towards the north-east the marshy land extends to a large lake stretching for about 12 miles in the same direction and forming the source of the south branch of the Red Paint river. This stream falls over a granitic barrier and passes through the aforementioned ridge in a denuded valley, after running a few miles through the level country. A succession of shallow rapids continues to a lake a few miles long, below which the river is broken by some short rapids to the junction of the north branch. Below the junction one long rapid with a considerable fall intervenes before the stream passes into quiet water which extends for five miles to Lake Nipigon. The north branch is a smaller stream uniting with the former about seven miles up; its course is somewhat south of west, and a slightly different country is shown in the more nnmerous lake expansions on its course which approximates to the Huronian-Laurentian contact. This branch also traverses the low-lying tract, but its head-waters are in the more elevated land farther to the east. About one-third of the way from its mouth, the Red Paint river receives a tributary on the north which drains a considerable depression stretching for eight to ten miles in that direction. This depression is occupied by a number of long narrow lakes with a general north-east and south-west disposition. Continuing northward from the source of the Red Paint, the low land extends to a lake forming the source of the Obabika. This lake is three miles long, and from it a stream, still in the low land, leads to a lake about seven miles east and west which discharges by a sluggish stream into a muddy lake stretching three miles north. This lake occupies the Lake Superior-James Bay divide and sends a stream in both directions. The former, the Obabika, continues in the swampy land to Cross lake, where the higher land is met and the waters begin to fall over the ridge towards Lake Nipigon. They continue in a south-westerly direction through a Laurentian region, the only considerable tributary entering from the south and arising in the same depression of which the southern drainage falls away to the Red Paint.

Red Paint river.

Height of land.

North of the Obabika several small streams, not navigable, enter Obabika bay in a south-westerly direction. The most southerly is the Kabasashkandagogama, draining a lake of the same name which is accessible, not by the river, but by a small stream entering the Obabika from the north.

At the north end of Obabika bay a stream known as the Jackpine comes in from the north, its lowest seven miles traversing a sand plain with jack-pine, above which point the country becomes more rocky and passes beyond the borders of our sheet. Sand plains.

GEOLOGY.

Three different formations can be recognized in the region—the Laurentian, the Huronian and the Animike. The Laurentian is represented by gneisses and granites varying from types with the most pronounced lamination to those of massive granitic structure. On the whole the rocks commonly classed as Laurentian, as far as this region is concerned, consist mostly of hornblende granite becoming gneissoid in places. An area of rock of this kind enters the northern boundary of the sheet at a point seven or eight miles from the north-east corner. It extends in a south-west direction to an apex a short distance west of Cross lake, where it again sweeps eastward and, after a considerable curve in this direction, reaches another westerly apex in the depression north of the Red Paint river. The line of contact then makes another easterly curve and turning west cuts off part of the Red Paint, finally reaching the shore of Lake Nipigon at a point just north of the mouth of this river. The area north and west of this broken line is occupied by Laurentian granites and gneisses, while that south and east is a region of Huronian schists. A second granitic area surrounds the large lake at the source of the south branch of the Red Paint, and seems to fringe the lake as a belt not over three miles wide. A third region of Laurentian rock lies inland about two miles from East bay. Like that just described, its centre is occupied by a large lake of eight miles extent, lying in a north-easterly direction which the rock surrounds as a narrow fringe. This is essentially a granitic type. Rocks of a more gneissoid appearance crop out along the shore of East bay, and in a south-east angle of Humboldt bay. I am inclined to regard these as a southerly extension of the large area of similar rocks already described. Geological formations. Hornblende granite. Three Laurentian areas.

Except along the lake and in a limited portion of the south-west corner of the sheet, the remaining area is occupied by Huronian rocks, generally tilted at high angles with a strike averaging a little north of east. The schists are usually of an acid type, apparently mostly of quartz-porophyry origin, mixed with volcanic clastics. Basic schistose bands occur with much less frequency, as well as limited belts of diorite and diabase. Huronian rocks.

Resting on the flanks of the northern Laurentian area, particularly south-east of Obabika bay, as well as in the north-east and south- Animike sandstone.

east angles of Humboldt bay, are small areas of white to pink coarse-grained sandstone, referable to the Animike series. Smaller outcrops of this rock also occur at a few points along the western shore of the south peninsula of Obabika. In every case these deposits are covered by a dark basic rock of diabase structure rising to an average elevation of 300 feet. This Animike trap forms the whole of the north peninsula of Obabika, and, excepting a narrow fringe where the underlying gneiss is exposed, the whole of the south peninsula of the same name. The third area, the one with which the sandstone is particularly associated, lies east of the isthmus of Obabika and extends about five miles inland. Livingstone point, south of Humboldt bay, is a narrow peninsula composed of trap at its eastern extremity. This rock overlies a bed of sandstone at the western end of the point and extends a mile or two inland as a narrow belt overlying the Huronian. The final trappean area forms a line of contact from the soath-east angle of East bay in a south-easterly direction for about eight miles, when it turns south and crosses the Sturgeon river at the top of the long rapids. The southern boundary of this area begins in a cove north of Poplar point, and stretches to the foot of the long rapids. It is this belt of trap that is responsible for the heavy rapids at this point.

Animike trap.

Contacts of trap and Huronian.

SOIL AND TIMBER.

Character of soil.

The height of land region at the eastern border of the sheet, though level and swampy, is mostly of a sandy nature as revealed in the river cuttings in the district. The rocky land farther west is covered, where any soil is developed, by shallow beds of sand, while the slope to Obabika bay and Lake Nipigon presents much more clay. Therefore, the best agricultural land in the region is to be found in a belt of about five miles width along the shore, particularly along Obabika bay and in the region immediately east of Humboldt bay. North of Obabika bay a little clay is found, but extensive sand plains cover it as we proceed northward.

Timber.

The timber in the height of land region is small spruce and tamarack with Banksian pine on the sand plains and higher land. The central rocky region is better timbered, particularly along the rivers, but extensive fires have wrought havoc with the once abundant wood in these highlands. Both for agriculture, and for timber, the best is to be found on the clay land bordering the lake. Along the north shore of Obabika bay fires have practically destroyed the timber. On the lower reaches of the Obabika, however, and in the depression connecting that river with the valley of the Red Paint good stretches of spruce, balsam, poplar and birch still exist. Also north of the Obabika towards the

Kabasashkandagogama and along East bay good timber is to be seen. The marketable spruce, which is really magnificent in this last region, has been unfortunately cut off a few miles east of 'Little Long' lake by an extensive fire from the south-west. All along the Sturgeon the timber is small, of about 20 years growth, while in the south-east corner of the sheet still younger forest is found. An attempt will be made in the final report to map the different areas of forest growth so as to bring out the disastrous effects of forest fires. For instance, one fire about five years ago started somewhere north of the mouth of the Sturgeon and swept across the country in a north-easterly direction, devastating the upper valleys of both branches of the Red Paint and stretching beyond into the basin of the Obabika.

ECONOMIC GEOLOGY.

Iron.—In the region lying immediately south of this sheet are three or four bands of Huronian rock sufficiently ferruginous to be known as the iron range. These deposits have already been described and need no further comment here. Both the Algoma Commercial Co. and the Flaherty syndicate, which have been engaged in extensive explorations on these ranges, have recently abandoned the region. This cessation of operations does not prove the worthlessness of the deposits, but merely that the expiration of options and heavy financial engagements elsewhere diverted the tide of prospecting from this region. Iron deposits similar to the above have been reported on the Red Paint river, but my observations, as well as the more detailed work of the above mentioned companies, failed to reveal any jasper bands, the infallible index of the iron range. One Andrew Green staked claims on Red Paint lake and at different points in the vicinity; the iron, however, is merely limonite and ochreous hematite in small masses, resulting from the decomposition of pyrite which occurs in certain sugary quartz seams running parallel to the inclosing schists. Iron ores.

Gold.—The Huronian rocks as usual carry small stringers of quartz, some of which may prove auriferous. On the south branch of the Red Paint, on Cross lake and on the upper portages of the Sturgeon good indications are seen, as well as on the streams over the height of land towards the Albany river. Specimens from the Obabika yielded traces of gold to the officers of the Crown Lands Department of Ontario. No indications of other metallic substances were seen. Of the non-metallic products certain of the fissile schists, particularly on the Sturgeon, would be useful for whetstones. Much of the clay along the shore line would be suitable for the manufacture of bricks and possibly would be of use for pottery. Gold.

Acknowledgments.

In closing, I wish to express to Mr. Edey of the Algoma Commercial Co., to Mr. Patterson of the Hudson's Bay Co., and to the officers of this company at Nipigon my sincere thanks for many acts of kindness during the summer.

Reconnaissance Surveys of Four Rivers South-west of James Bay.

Mr. W. J. Wilson.

Instructions.

Your instructions directed me to explore and survey the country lying between the Attawapiskat and Albany rivers, and also the country between the Albany and Moose rivers on the west coast of James Bay. In the first place you pointed out that the Kapiskau river would afford an easy means of access to the former region, and that there was reported to be a canoe route from Moose Factory to Fort Albany which followed branches of the Moose and Albany rivers flowing through the centre of the latter area; also to make a micrometer survey of the Abitibi river from the upper crossing of Niven's line to Moose Factory and to run a micrometer line from the latter point to the crossing of Niven's line on the Moose river.

Itinerary.

I left Ottawa on the 24th of May, accompanied by Mr. Owen O'Sullivan of this office as assistant, and proceeded by the ordinary canoe route from Lake Temiskaming to Moose Factory. We engaged two Indians at North Temiskaming and one at Abitibi Post who remained with us all summer, and besides these three we employed guides for short periods, who knew the different rivers we had to explore.

Kapiskau river.

We reached Moose Factory, June 20, having been delayed very much by stormy weather. We went from Moose Factory to Fort Albany in our canoes along the coast, and after securing a guide and supplies for six weeks we continued in a boat to the mouth of the Kapiskau river, which we reached July 2. We made a micrometer survey of this river for 200 miles up. At this point the numerous short bends in the river made progress so slow that it was deemed advisable to stop micrometer work and separate into two parties. This we did July 21. I followed the main stream making a track survey for about eighty miles, and I also explored some of the larger branches as far as I could ascend them with a canoe. Mr. O'Sullivan returned to the forks forty-four miles up from the mouth and made a track survey of the south branch called Atikameg (Whitefish) river by the Indians. He continued up this river 135 miles.

Atikameg river.

* Dr. Bell's report for 1869. describes the geology of both sides of Lake Nipigon and that for 1871, the geology of the Obabika river and the route thence north to the Albany.

Having completed the examination of the two principal branches of the Kapiskau, we returned to the mouth of the Otadaonanis river, a large tributary which joins the main stream four miles from James' bay. Here Mr. O'Sullivan remained to make astronomical observations and to extend the micrometer survey out to the bay, while I made a track survey of the branch referred to above. We then returned south, Mr. O'Sullivan making a track survey of the coast between the mouth of the Kapiskau and Fort Albany. At the latter place we again separated to examine the country between the Albany and the Moose rivers. Mr. O'Sullivan went up the Albany to the upper end of Big island where a large river, called by the Indians the Kwataboahegan, enters from the south. He explored this river to its source. It forms part of a canoe-route between Moose Factory and Fort Albany used by the Indians only at high water, but no one seemed to know whether it would be possible to go through at this season, (August 11). The branch which forms the southern part of the route is known by the same name and enters the Moose river about fifteen miles south of Moose Factory, measured along the common canoe-route. The Albany branch is also known by another name which means Stooping, river, and to prevent confusion I have used this name on the accompanying map. Returning from Fort Albany to Moose Factory, I made a track-survey of part of the coast. On the 16th August, I reached the mouth of the Kwataboahegan river, on the Moose side, and began a track-survey of it, which I continued for ninety miles up. Having met Mr. O'Sullivan, who was successful in getting through, we completed the examination of this river and returned to Moose Factory, where we repaired our canoes and got supplies for the trip home. Leaving this post early in September, we made a micrometer survey of the Moose river up to the intersection of Niven's line, (1898) a distance of thirty-one and a half miles. We then returned to the Abitibi river and continued the survey up that stream to the intersection of Niven's line, at the 179th mile post, connecting with my survey of last summer. This completes the instrumental survey from Moose Factory to Lake Temiskaming by way of the Abitibi river and lake, and the canoe-route to Quinze lake. We finished the survey September 24, and came directly to Ottawa which we reached October 8.

Otadaonanis river.

Kwataboahegan river.

Abitibi river.

THE KAPISKAU RIVER.

The Kapiskau is about a quarter of a mile wide for some distance from the mouth and has a width of from seven to ten chains to the forks. At forty miles up, a section was made which showed that the volume of water at this point was 566,000 cubic feet per minute (July 4). The width is seven chains with an additional three chains

Kapiskau river.

for ordinary high water, and the greatest depth is eight feet. The current is swift and strong with frequent rapids which become more numerous as the river is ascended up to 212 miles. Then for a distance of twenty miles there are only a few rapids and moderate current, followed by thirty miles of swift water and rapids. Above this there is almost still water to the Kapiskau lakes and for some distance beyond. The fall in a few rapids amounts to three or four feet, but for the most part it does not exceed one foot, and many of them are mere ripples which I presume disappear in high water. In the whole distance travelled on this river, we did not require to make a single portage.

Character of river valley.

The river has no distinct valley, but has cut its way into the thick clay covering that overlies the solid rock or into the soft rock itself. The banks are generally low, rising from five to twenty feet, and usually the land along the river for four or five chains back is higher than that farther away. The sediment deposited by the river when it is swollen by the spring freshets has accumulated year after year and has slowly built up a ridge close to the stream. It is also possible that the ice may have assisted in piling up the material along the banks in the same way that the shooting dykes are formed along the rivers in eastern New Brunswick and Prince Edward Island. This narrow ridge is well wooded where not burned, with large spruce, poplar, and at some distance from the coast, canoe-birch, fir, balm of Gilead and an occasional tamarack and cedar. The tamarack here has escaped the ravages of the larva of the imported larch sawfly that has done so much damage to it farther south, so that where it does occur it is green and healthy. Back from the river five, or six chains, the trees are much smaller and in many places nothing is seen but muskeg thinly covered with stunted spruce and tamarack two to eight inches in diameter, and an abundance of laurel (*Kalmia angustifolia*) and Labrador tea (*Ledum latifolium*).

Forest growth.

Clay, sands and shells.

For the first 125 miles the banks are composed of bouldery clayey and stratified clay and sand containing marine shells. At this distance the first rock exposures appear. The rock is a very soft reddish-brown argillaceous limestone mottled with greenish-gray spots and some layers are wholly of the latter colour. In places layers of the two colones alternate. The beds as far as observed are horizontal. Near the surface where the rock is exposed to the weather it is broken up into small pieces, and when wet very readily changes into mud, but in digging down much larger and firmer masses are found. The rock where first seen and for several miles up the river, is so soft that the river banks are worn down just the same as clay banks, and no cliffs are seen. This continues up for more than fifty miles from the

first exposure, when a considerable change takes place. At the 183rd mile of the micrometer survey a cliff nearly thirty feet high occurs, a section of which is as follows in descending order:—

Section of limestones.

	Feet.
Grayish limestone in angular blocks, firm	3·0
" " " much broken, soft....	1·6
" " " slightly mottled with red ..	1·3
" " " very soft...	0·6
" " " mottled with red, fairly firm	1·5
" " " very soft	0·7
" " " mottled with red	1·3
Grayish and reddish linestone very finely broken	0·4
Reddish limestone mottled with gray................	1·8
Grayish limestone, very soft.................... ...	0·2
Reddish limestone, crumbling........................	1·2
Grayish limestone, firm......	1·0
Mottled reddish and grayish limestone, very soft... ...	1·3
" " " " firm........	1·1
" " " " washed and covered by the river at high water.	10·1
	26·3

For twenty-two miles above the point where this section was made occasional outcrops of similar rocks are exposed along the banks, but for the last ten miles they are considerably firmer and of a light yellowish or buff colour. This is well seen at the last micrometer station, 200 miles from the coast. Only one more exposure of rock was seen and that was about five miles farther up the stream, or 205 miles from the bay. These distances are given from the micrometer survey and of course follow all the bends of the river, and this makes the distance much greater than if measured in a straight line. No fossils were found in any of these rocks but in their lithological characters they resemble very closely the Devonian rocks at the Sextant rapids, Abitibi river, where there are bands of the reddish and grayish rocks which both in the ledge and in hand specimens are identical with those on the Kapiskau river. The rocks on the Abitibi underlie beds containing typical Devonian fossils.

Limestone outcrops.

For 175 miles up the Kapiskau river the country is as flat as it can be and not the slightest elevation is apparent. At the end of this distance, however, the character of the country somewhat changes and for the next 25 or 30 miles up the monotony is relieved by low hills 75 feet high which give a rolling aspect to the country. These hills were evidently formed by erosion and are comparatively level on the top. This area is drier as the soil contains much sand and is covered for the most part with a thick second growth of poplar and canoe-birch with many dry trunks of trees standing or lying scattered over the ground. Going west up the river, the land again becomes flat and the current is

Level country.

not so swift or the rapids so numerous, and at 260 miles the stream becomes much broader and forms a lake-like expansion of comparatively still water for six miles, when it opens out into a small shallow lake. This lake is only one mile long and half a mile wide, but is of some importance as it gives the name to the river. When approaching this lake in a canoe there is no channel or passage visible as it is filled with tall scouring-rushes (*equisetum*) and the canoe has to be forced through these across the lake. The word Kapiskau means obstructed or blocked up and was first applied to this lake and afterwards to the river. For the next mile the river flows from the north-west in a sluggish broad stream with marshy banks, and again expands into a narrow lake running north and south for three miles. At the extreme north end, the river enters and for four miles is almost dead water, after which it has a swift current with occasional rapids as far as it was followed, a distance of seven and a half miles from the lake. At the point where I turned back the river was from 30 to 40 feet wide and in places four feet deep, while in other places there was not enough water to float a canoe. It was blocked every few chains with log jams and fallen trees which reach from bank to bank. We had to cut our way through these and this made progress so slow that I decided to return, having first climbed a tree which gave a view of the country for a long distance and nothing could be seen but a broad plain covered with ragged bush with an occasional clump of large green trees mostly spruce, poplar and tamarack, but the area within a radius of five or six miles that is so covered in any one place is small. A small stream enters the largest of the Kapiskau lakes from the west but it proved to be full of boulders, driftwood and rapids so that it could not be navigated by canoes for more than a mile.

Character of Kapiskau river.

Gravel ridge.

Half a mile west of the south end of the lake there is a ridge which, though only 75 feet above the level of the lake stands out prominently from the level country. An examination showed that it is composed chiefly of gravel. It has the form of a kame and is about 20 chains long and 500 feet wide. It is sparsely covered with Banksian pine, canoe-birch and poplar. Viewed from this elevation the whole surrounding country is a vast plain. The only rise to break the monotony is a slight elevation five or six miles to the north. There is a small lake a mile to the south and peaty swamps are common. These are covered with small spruce and tamarack, and the drier ground with second growth poplar and canoe-birch. The aneroid readings give an elevation of about 400 feet above sea level at these lakes.

Elevation.

Large areas are covered by peat bogs, especially along the upper stretches of the river and often the top layer along the almost perpendicular bank is composed of peat four or five feet thick.

On my way down the river I examined some of the larger branches for seven or eight miles up and found the country in no way different from that adjacent to the main stream.

THE ATIKAMEG RIVER.

Mr. O'Sullivan reports that the Atikameg river, which he surveyed for 135 miles from the forks, presents the same characters as the main stream. There is a swift current and numerous rapids, and the upper part is very crooked with many short bends. The banks are composed of bedded and boulder clays and are from ten to twenty-five feet high. The forest growth, close to the river, consists of spruce, poplar, tamarack, canoe-birch and fir. The spruce averages from six to twelve inches, with occasional trees twenty inches or more in diameter. Back five or six chains, from the river banks, the land is open swamp and muskeg, covered with small spruce and tamarack. No rock exposures were seen on the lower part of this river. The first rock in place is 100 miles from the forks and is a flat-lying, honeycombed light yellowish dolomitic limestone. Some of the cavities are partly filled with a white mineral, which on exposure to the air crumbles into powder. Some of the layers are harder and have fewer cavities. A rock of this character is seen one mile and three-quarters farther up the river. Four miles and a half above this, the soft, grayish limestone, already mentioned as occurring on the main branch, was observed. Rocks similar in character to those seen at these three places occur at intervals almost as far as the river was examined. The specimens collected show that some of the strata are much harder than those of the Kapiskau river. Where Mr. O'Sullivan turned back, the aneroid gave an approximate elevation of 375 feet.

Atikameg river.

Forest growth.

Elevation.

THE OTADAONANIS RIVER.

At high water this branch is navigable for canoes almost to its source and forms a canoe route to the Albany river, by a portage connecting its head waters with the latter.

Otadaonanis river.

It is two and half chains wide at the mouth and I was able to ascend it forty-five miles, though the water was comparatively low. Its general course is north-east and it runs close to the main river as well as to its principal branch, the Atikameg. The banks are composed of clay containing the usual boulders and shells. No rock exposures were seen, but small heaps of the reddish and grayish mottled limestone were lying on the banks as if deposited there by melting ice pans, and indicate that the rock is probably in place farther up the stream.

Clay, sand and shells,

The clays exposed along the banks of the Kapiskau and its branches show considerable variety. Near the coast an unctuous bluish-gray clay is overlaid by ordinary sandy clay. Farther up the river, typical boulder clay full of striated boulders occupies the lower part, with more or less stratified material on top. There is no sharp line of separation between them, as they seem to merge into each other. In places there are thin bands of peaty material containing plant remains. Still farther up the banks are higher and the material much more sandy and gravelly, often showing false bedding. Generally the upper layers contain marine shells with few boulders, while the lower part is decidedly bouldery. Thinly laminated limestone concretions are common, usually circular in form, but as far as examined they contain no fossils. For 125 miles up the river there is no means of estimating the exact thickness of the clay covering, but above this, where it rests upon the solid rock, it varies from ten to seventy-five feet. A section six miles above the forks gives, in descending order :—

Stratified clay..............................	10 feet.
Bouldery "	20 "

Bouldery clay.

The bouldery clay is very much like the overlying stratified clay in general appearance, and is of a dark slate colour, but shows no stratification and contains no fossils.

Limestone fragments, both rounded and angular, are common in the clay; also a dark very fine grained argillaceous arkose or graywacke with spheroidal pseudo-concretions of a lighter colour, which by differential weathering are sharply outlined. The cavities thus formed vary in size from mere specks to six inches or more in diameter. In section, examined by Mr. O. E. LeRoy of this office, the pseudo-concretion is seen to consist of angular and rounded fragments of clear quartz and turbid feldspar, shreds of biotite, muscovite and brown sphene imbedded in a matrix of calcite. The centre of the area is occupied by an oval-shaped fragment of fine clay slate. No concentric structure is apparent. The main mass of the rock differs in having a clay or kaolin matrix. These boulders are the most widely distributed and probably the most numerous of all the boulders in the drift, and are found on the west coast of James bay and all the rivers examined in this vicinity. Dr. Bell states that they extend all the way south to Lake Superior and that the rock is found in place on Long island, off Cape Jones, on the East Main coast.* Besides these there are well rounded boulders of red and gray granite, gneiss, reddish conglomerate containing jasper pebbles, greenish

*Report of Progress, Geol. Surv. Can. 1886, vol. II, (New Series,) pp. 20G and 36G.

breccia containing pyrite; banded jasper, jaspilyte, several iron ores of low grade; hornblende schists; diorites, etc. Some of the jaspery iron ores are identical, as far as can be judged from hand specimens, with those collected by Dr. Bell and Mr. A. P. Low on the east coast of Hudson bay, and they also resemble very closely iron ores found in situ on Sutton Mill lake by Mr. D. B. Dowling. Iron ores.

The shells, etc., found in the clays of the Kapiskau river as determined by Dr. J. F. Whiteaves, are as follows:—*Saxicava rugosa, Macoma calcarea, M. Balthica, Cardium ciliatum, Mya truncata, M. arenaria, Leda buccata, Mytilus edulis, Seripes Groenlandicus* and *Balanus crenatus*. The shells of *Saxicava rugosa* are very large, one specimen measuring one and seven tenths inches in length, and three quarters of an inch in width. The first two in the above list are by far the most common and are found everywhere. No striæ were observed except on boulders as the soft rock where exposed had weathered and disintegrated. Fossils.

JAMES BAY.

The most noticable feature of the west coast of James bay is its extreme flatness. Looked at from a distance there is no distinct shore line but the water and land seem to merge into each other. A strip varying in width from one to three miles and partly covered with grass and low shrubs, extends along the coast from the Kapiskau to the Moose river, except for a few miles north and south of Cockispenny point where the shore is fairly high and dry and the trees come to the water's edge. At this point one can land with canoes almost any time, but elsewhere the water is very shallow and at low tide. bare mud flats extend out for miles. Gravelly ridges with numerous boulders are very common and form one of the serious obstacles to canoeing along the coast. Coast of James bay.

At Cockispenny point I noted the reddish-brown and grayish limestone that has been already described as occurring on the Kapiskau. Farther south at Pisquochi large masses of a light gray and dark buff limestone containing the Devonian fossils *Spirifer divaricatus* and *Streptelasmam prolificum* were observed. There seems to be little doubt that these rocks are in situ. Fossils.

THE KWATABOAHEGAN RIVER.

This river enters the Moose river by two channels separated by a triangular island. The north chanuel is the larger, but has two bad rapids. The river is broad, shallow and rapid and flows over flat-lying, Kwotaboahegan river.

fossiliferous limestone for thirty-two miles. When the water is low it is with difficulty it can be ascended, but this is much the best time to examine the rocks, as it is only at comparatively low water that the beds in situ can be seen. Near the mouth the rock is a light grayish limestone dipping S. W. $< 10°$ and containing numerous fossils. Farther up it is horizontal and of a light brownish colour. These rocks resemble very closely those on the Moose and Abitibi rivers and contain the same fauna.

Fossils.

The following fossils were collected from these rocks. The Brachiopods, etc., were identified by Dr. J. F. Whiteaves and the Stromatoporoids and Corals by Mr. Lawrence M. Lambe :—

Stropheodonta concava, Hall.
Spirifer divaricatus, Hall.
Atrypa reticularis (L).
Pentamerella, sp. indet.
Modiomorpha, sp. indet.
Spathella, like *S. subelliptica*, W.
Conocardium cuneus, var. *trigonale*, Conrad.
Platyostoma, sp. indet.
Cyclonema (?), sp. indet.
Loxonema, sp. indet.
Gomphoceras beta, Hall.
Orthoceras, sp. indet.
Phacops, sp. indet.
Proctus, sp. indet.
Portions of Crinoidal Stems.
Diphyphyllum arundinaceum, Billings.
Syringopora Hisingeri, Billings.
Cyathophyllum exiguum, Billings, sp.
Cyathophyllum Halli, Milne-Edwards and Haime, sp.
Cladopora cryptodens, Billings, sp.
Actinostroma expansum, Hall and Whitfield, sp.
Favosites hemispherica, Milne-Edwards and Haime.
Phillipsastræa Verneuili, Milne-Edwards and Haime.
Syringopora nobilis, Billings.

Peat.

At sixty-five miles up there is a large quantity of a solid peaty material in the bed of the river. The mass where examined was six feet thick and it can be traced along the river for 430 feet. It is of a dark brown colour and breaks off into lumps two to three feet thick. It burned slowly in the camp fire, but left a large quantity of ash, and an examination of a specimen made by Dr. Hoffmann in this office

showed that it would be useless for fuel unless it occurs in other places much purer than the specimens examined. Thin layers of the same material are exposed in the bank intercalated with the clay for several miles up the river, but everywhere they were impure.

As stated above, this river was examined for a distance of ninety miles, and from Indian sketches and descriptions, I infer it continues westward forty or fifty miles farther, though where I turned back it was with difficulty it would be navigated with a light canoe. Rapids are common along its whole course and it was necessary to make three short portages to pass the large ones. These rapids could have been poled up if the water had been sufficiently deep.

Character of the country.

The land along the whole course is low and swampy, and as on other rivers examined in this country, there is a dry ridge of a few chains width along the banks and then low swampy ground covered with small spruce and dead tamarack. The principal trees are spruce, the largest being from one to two feet in diameter and the average six to eight inches, tamarack mostly dead, poplar, balm of Gilead, fir and an occasional canoe-birch, and on the upper parts cedar is common. Willows and alders and other shrubs line the banks. Some of the spruces are tall and straight and would make good saw-logs or pulp wood, but trees of this kind are only seen close to the rivers. For the most part where the land is at all dry the trees are crowded together as closely as they can stand and this tends to stunt the growth of all. Patches of second growth ten to twenty years old occur along the river and there are areas of considerable size burned within one or two years.

Agwasuk river.

At seventy-five miles up, the canoe route leaves the river and follows a small tributary to the north called the Agwasuk. This stream is connected by a portage of a mile across the height of land to a lake which drains into the Albany river, the stream entering the Albany near the head of Big island.

THE STOOPING RIVER.

Stooping river.

In following this route from the Albany, Mr. O'Sullivan noted a light yellowish limestone two and a half miles from the mouth. The fossils in these rocks show that they belong to the Devonian system, probably Corniferous. This river for the greater part of its length forms a fairly good and easy canoe-route. It flows between clay and sand banks in places twenty feet high, with shells and boulders common to all this country. The adjacent country is reported to have been burned eighteen or twenty years ago, so that now there is a second growth of spruce averaging four to eight inches in diameter, with a

few small trees of poplar, tamarack and birch. Back from the river, the land is low and swampy and partly covered with the usual small trees. The two lakes near the source of the river lie in a flat swampy country the general elevation of which is about 275 feet above sea level. The largest, four miles long and two miles broad, is called Sand Bank lake and it is from it that the portage connects through an open swamp with the Moose waters. The stream into which the portage is made is small and very crooked and so overgrown with willows and blocked by fallen trees and old beaver dams that it was with the greatest difficulty a canoe could be got through, and for the twenty-three miles to the main river the stream is rough and difficult.

Clays and fossils.

The clays, boulders and pleistocene fossils on this river are identical with those on the Kapiskau except that the local limestone boulders are more numerous in places along the Kwatoboahegan. One mile from the mouth striæ occur on the limestone rocks, and also a mile farther up on the south side of the first long island. The course is S. 14° W. and S. 29° W. of the true meridian. There is no distinct stossing, as the limestone lies flat, but after a careful examination I have no hesitation in placing the direction as above.

Peat beds.

Reference has already been made to thick beds of peaty material on the Kwataboahegan river and thin layers of the same kind on the Kapiskau river. Similar thin layers of the same kind were also observed along the lower Abitibi river and also a thick stratum of lignitified wood. The thin layers seem to be intercalated with stratified clay while the larger masses are overlaid by a considerable thickness of bouldery clay which forms the lower part of the surface deposits along these rivers. I was not able to penetrate through the beds of peat and lignitified wood so as to see whether they rest on boulder clay or stratified material. It seems probable, however, that they are interglacial, and if so, judging from the thickness of the beds, a somewhat lengthened period must have elapsed from the retreat of the first glacier to the advance of the next. The striæ and surface deposits of the country to the south clearly point to two or more separate movements of the ice.*

Track surveys checked.

All the track surveys made were constantly checked by astronomical observations, and in the case of the Kwataboahegan river I was able to make a paced survey of much of the lower part by walking along the banks.

*Summary Report, Geol. Surv. Can., 1901, pp. 126, 166.
Glacial and Inter-Glacial Deposits near Toronto, by A. P. Coleman. Journal of Geology, vol III; No. 6, 1895.

CLAY BANKS ON KWATABOAHEGAN RIVER, ABOUT 70 MILES FROM MOOSE RIVER.

Kwataboahegan River just below the mouth of the Agwasuk Branch, 1902.

The latitude and magnetic declination of the following places are :—

—	Latitude.			Magnetic declination.		
Mouth of the Kapiskau river..................	52°	45′	45″	12°	10′	25″
Mouth of the Atikameg river.........	52	29	40			
200 miles up the Kapiskau river.......	51	55	0	7	7	36
Fort Albany............	*52	14	28	11	45	0
Cockispenny point, James bay	52	0	0			
Moose Factory (Ogilvie)..........	51	14	42			
Niven's line (Moose river)				11	0	0
Sand Bank lake, north end of portage	51	3	30			

*This latitude is the average of Mr. D. B. Dowling's and ours.

THE ABITIBI RIVER.

From the mouth to the Sextant rapid the Abitibi river is broad, rapid and shallow and studded with numerous islands, some of considerable size and great beauty. Islands Abitibi river.

The banks are high in places, reaching thirty or forty feet and are composed of clay, sand and gravel and are well wooded with black and white spruce, poplar, fir, birch, balm of gilead, cedar and tamarrack with numerous shrubs. Above the Sextant rapid the river is narrower and deeper and has a fairly strong current. The banks are mostly clay, often high and almost perpendicular with hills rising behind to a height of 100 to 150 feet. Up to the Otter portage there is much swift water with some rapids. At this portage the river contracts to about one quarter its usual width and for nearly two miles flows through a winding gorge with high rocky walls. Looking down from the portage it presents a wild and picturesque appearance. A large area around this point was overrun by fire in 1901, both sides of the river. The Otter portage is 152 chains long. From this to the Long portage the river flows between well wooded high banks and is about fifteen chains wide. Numerous gravel terraces occur along this tract. From New Post up, the forest is second growth about fifteen years old.

The roughest part of the river begins at the foot of Long portage, above which is the belt of eruptive rocks already referred to, and continues for nearly eight miles in a series of rapids. The Long portage is 141 chains in length and has a bad hill at the north end. Across a small bay a very swift rapid is passed by the Oil Can portage, then follow Birch Bark, Clay Falls, Rocky and Lobstick portages. Birch Bark is thirty chains, and Lobstick thirty-three and a half long, Long portage

but all the others are short. Above these rapids the river bends to the east for nearly two miles, then its course is almost south. At the last bend there is a trail which connects with six small lakes and joins the river between the Oil Can and Long portages. This route necessitates making seven portages aggregating five miles, but when the water is high the river is too dangerous for small canoes and the latter route has to be used. From this point south to Niven's base line, 1900, just belew Island portage, the current is moderate and the clay and gravel banks are lined with terraces. There are rounded hills. rising to a height of 150 feet or more above the river level, and covered with small poplar, canoe-birch, spruce, fir, cedar and dead tamarack, but for five or six miles below Island portage, black spruce is the prevailing tree. Island portage is on a small island and is required to pass a rough rapid, and just south of the island there is another short portage on the west side. The rapids here, however, can be run, or poled up by ordinary canoes when the water is not too high. Numerous islands occur up to the Three Carrying Place portage and the current is rather strong. At this place there are two swift rapids with a fall of fifteen feet or more. These are passed by two short easy portages on the west side, or one rather long and difficult one on the west bank. In going up the river to the Frederick House branch two fair-sized streams are passed, Singed Martin creek and Driftwood creek. Just below the mouth of the Frederick House river a section of the main river was made, September 22, which showed that at this point it has a volume of approximately 401,000 cubic feet per minute. The width here is thirteen chains and the greatest depth seventeen feet, but the current is slow.

Section made of river near mouth of Frederick House river.

In ascending, the river turns abruptly to the east and continues in that direction for ten miles and a half. Kettle Falls portage is on the south bank and about two miles from, the bend. Another short portage is necessary to overcome a swift rapid about midway on this stretch and for the greater part of the way to where the river turns south the current is swift and strong.

At the bend to the south, Jaw-bone creek enters, and the river from this point to the crossing of Niven's line is about ten chains wide and flows with a moderate current. This point connects with the micrometer survey made by me last summer up to Speight's trial line below the Iroquois falls.

On our way up the river we made a section between the Couchiching falls and Lake Abitibi which gave the approximate volume of the water at this point 306,000 cubic feet per minute. The width of

the river here is six chains and the greatest depth forty-two feet, with a slow current.

Geology of the Abitibi River.

The lower part of the Moose river flows over Devonian limestones, and the same is probably true of the Abitibi up to the Sextant rapids, a distance of seventy-two miles from the mouth.

At the mouth of the Abitibi there is a rapid, passed by a portage on the west bank. The fall is about eighteen feet over ledges of a buff coloured limestone weathering white and dipping slightly to the south-west. This rock is seen in places for five or six miles, but contains no fossils as far as examined. For the next fifty miles no rock exposures are seen, but there are deep cut banks of clay containing marine fossil shells and in the lower part many boulders. The banks are well wooded and much of the soil along the river is of excellent quality, being for the most part a rich sandy loam.

Big Cedar creek.

Opposite Big Cedar creek, in the west bank there are seams of impure peaty material two to three feet thick intercalated with the clay. These beds are overlaid by ten to fifteen feet of clay, in part stratified, and they are exposed at intervals for a considerable distance. Forty miles from the mouth of the river, at what is called Blacksmith rapid, there is an outcrop of lignite or lignitified wood. On the east bank we sank a hole into it to a depth of nearly five feet, when we got below the level of the river and water coming in prevented us reaching the bottom of the seam. Much of the material taken out was loose and comparatively fine and coaly, but some of it was woody and firm and showed the vegetable structure clearly. Fine seams of sand were occasionally met with in digging into the mass, but these were less than an inch thick. Many specimens of plant remains were found but they have not yet been identified. Some of the specimens collected have broken up on exposure to the air and show a bright shiny surface. About ten feet of bouldery clay overlies and covers up the bed on the sloping bank and makes it difficult to trace it for any great distance, especially in the absence of any proper instruments to dig with. The Indian guide reported that thin seams of this coaly material occur on the Kisagami river (West river, of the Northern Ontario map, 1900) below the large bend where the first portage is made. Similar exposures have been described on the Missinaibi river and its branches to the west by Dr. Bell and others.* This material

Lignite possibly of economic importance.

* Report of Progress, Geol. Surv. Can., 1875-76, pp. 326-327, and 1877-78, pp. 4-56. Report on the Basin of Moose river and adjacent country, by E. B. Barron, 1890.

may be of considerable economic importance as it evidently spreads over a wide area and if it can be found in large enough quantities would be a useful fuel for local purposes. In proceeding up the river thin bands of impure peat are occasionally seen close to the water level for the next fifteen miles.

Sulphur spring

Fifty-five miles up an exposure of gray shale dipping S. 30° E. < 10° outcrops on the west bank. The topmost layers are very fissile and soft, while at the level of the water they are thicker and slightly firmer, but still soft. This is near the foot of the Long rapids, and other exposures of a similar kind are seen farther up for over three miles. A sulphur spring is situated on the west bank about a mile and a half above the first outcrop of shale and is covered at ordinary high water. Outcrops of a grayish, fossiliferous limestone are met with in the upper part of the long rapids associated with layers containing cavities partly filled with calcite crystals, and others of fine grained, evenly-banded strata. For six miles below the second portage on the river there are no rock exposures, but high clay banks. The rapid causing this portage falls about six feet and runs through a mass of porous, granular, dark-brownish limestone weathering white and holdingfossil corals. The cliffs on either side are twenty feet high. On account of the abundance of the corals in the rocks at this point I propose to call it Coral rapid. Between this portage and the Sextant rapid the limestone is from yellowish to reddish-brown in colour and full of fossils, especially corals. Just below the Sextant rapid there is a high cliff on the east side of alternate hard and soft bands mostly of a grayish limestone, but containing in the lower beds the reddish-brown clayey limestone similar to that found on the Kapiskau river and at Cockispenny point on James bay. Some of the uppermost layers contain fossils.

Fossils identified.

From the fossils collected along this river Dr. Whiteaves and Mr. Lambe have identified the following species, all indicating a Middle Devonian horizon :—

Cyrtina, sp. indet.
Atrypa reticularis (L).
Paracyclas elliptica, Hall.
Cyathophyllum Halli, (Milne-Edwards and Haime.)
Streptelasma prolifica, (Billings.)
Phillipsastræa Verneuili, Milne-Edwards and Haime.
Stromatopora tuberculata ? Nicholson.
Stromatopora, sp. Cfr. *Stromatopora Hupschii* (Bargatsky.)
Favosites turbinata, Billings.

Favosites basaltica, (Goldfuss.)
Favosites cervicornis, Milne-Edwards and Haime.

Petrographical descriptions.

At the south end of the Sextant portage there is a layer of sandstone underlain by several feet of conglomerate, and below this, masses of a dark augite rock forming the bed of the river. Across the river on the west bank at water level there are thinly laminated gray shales containing fossil plants. Above the shales and lying conformably there are beds of conglomerate, and on top of this seemingly bedded eruptive rocks similar to those on the east bank. The petrographical descriptions which follow are by Mr. O. E. LeRoy of this office. Of specimens from both sides of the river at the above point, he says: 'The hand-specimens represent a very dark almost black augite lamprophyre of a type closely allied to the monchiquites. The section consists of aggregates of calcite and serpentine as pseudomorphs after olivine, and pale brown and pink idiomorphic augites in a ground mass of augite, shreds of biotite, calcite, chlorite, magnetite and a fibrous zeolite.'

Strata cut by probable dyke.

At the north end of the rapid what looks like a dyke cuts diagonally through the strata from top to bottom, but I did not make a close examination.

About a mile south of this portage on two small islands the first Laurentian rocks are seen, where there is an exposure of reddish granitoid gneiss. The same rock outcrops at the north end of the Otter portage much disturbed and broken and intersected by pegmatite veins. This portage leads across exposures of micaceous rusty gneiss near the north end where the foliation is distinct and the strike east and west. At the south end there is a garnetiferous gneiss dipping N. 60° E. < 45 cut by dioritic dykes one to four inches wide. Several exposures of granite and gneiss striking in a general way east and west are seen along the river up to two miles from the Long portage. Here the rock is a 'pink and light gray pegmatite, consisting mainly of feldspar with subordinate quartz and biotite. The section shows an alltriomorphic structure, the feldspar (orthoclase, microcline, oligoclase) occurring in large irregular individuals with smaller grains occupying the interstices. The quartz occurs in definite areas. Limited alteration has gone on in the plagioclase, producing calcite, epidote, and zoisite, while the biotite is almost completely altered to carbonates and limonite.'

Rocks at north end of Long portage.

At the north end of the Long portage the character of the rock changes. It is felsitic and much broken and shows irregular lines running north and south. A short distance south at the Oil Can portage the rock is an olivine hypersthene gabbro, dipping N. 45° E. < 75. 'It is a dark, rather fine-grained type, composed of black

pyroxene and rusty feldspar, the whole having a rudely foliated structure. Microscopically the rock is composed of diallage, hypersthene, olivine, plagioclase, with accessory magnetite, pyrite and apatite and secondary serpentine. The minerals occur in polygonal and rounded forms with smooth borders. Pale gray diallage with the usual microstructure is the dominant pyroxene. The hypersthene is pleochroic in tones ranging from rose red to a faint green; the olivine is colourless and is more or less altered to serpentine. The feldspar is probably labradorite; it is twinned according to the albite law with additional pericline in some cases. With crossed nicols evidence of strain is apparent from the undulatory extinction, and the bent and broken twin lamellæ. The structure is that of the eruptives usually classified as Laurentian.' From the Oil Can portage to Rocky portage the rock is coarser, but a representative specimen taken two and a half miles from the last shows that the rock is an olivine gabbro. The structure is similar to that of the specimen just described but the mineral content differs in that hypersthene is absent while biotite is present. The iron ore is ilmenite with a border of leucoxene.

Rocky portage. At the Rocky portage there is an outcrop of well foliated rusty gneissic rock striking N. 80° W. At the south end the dip is N. < 75° with coarse pegmatite veins cutting the strike. These rocks continue up to the Lobstick portage where a garnetiferous biotite syenite rock appears. 'This is a fine grained rather basic dark red rock, holding a very large amount of garnet in grains and rhombic dodecahedra. The garnet is much cracked, and perfectly isotropic; it holds inclusions of feldspar and biotite in a poikilitic manner. The feldspar is a finely twinned plagioclase, in all probability albite. Biotite in irregular plates and idiomophic forms with skeleton structure occupies spaces between the feldspar and garnet. A few grains of apatite and zircon complete the section. The rock from its association may possibly be referred to the Grenville series.'

A short distance above the portage, gneissic rocks again outcrop, and on an island a mile and a half distant near where the river turns south the dip is N. < 75°. No rock exposures were seen along the river for the next seventeen or eighteen miles, the first appearing a little more than half a mile below Niven's base line north of Island portage. Here the rock is a 'biotite granite or granitite, coarse grained, and made up of gray and pink feldspar, black mica and hornblende, and quartz. Under the microscope the feldspar occurs as albite, orthoclase and microcline, the former predominating. Associated with the biotite is a little pale green hornblende which includes the magnetite. Quartz, apatite, zircon and muscovite complete the

section." On Island portage there is a slickensided rock which under the microscope proved to be a sheared portion of the above, the 'section showing a granulation and alteration of the minerals with attendant development of kaolin, chlorite and calcite.' Adjacent to this rock are masses of gneiss dipping S. E. < 50°, but they are very much disturbed and broken up. One or two exposures of this slickensided rock are seen in the next two miles with intervening outcrop of gneiss and granite, which are the principal rocks in the river up to Niven's meridian line of 1898. At the Three Carrying Place portages on the east bank the foliation of the gneiss is very distinct; the dip is S. 70° E. < 50° and on the second portage ascending the river it is N. 80° E. < 32°. At this point there are bands of almost pure quartz. One mile and a half below the mouth of the Frederick House river on the east bank there is a reddish massive granite, chiefly quartz and feldspar. At Kettle falls the gneiss is composed of alternating bands of red and gray feldspar, quartz, mica and hornblende. The dip is S. 40° E. < 35°. A hand specimen taken at this point is a 'granitite gneiss, well foliated, light gray in colour and is one of the most acid types. The microscope shows the feldspar to be present both as orthoclase and plagioclase (albite), which occur in irregular individuals with a somewhat interlocking habit. Strain shadows prevail both in the quartz and feldspar. The biotite is in part idiomorphic, and includes or is associated with zircon, apatite, epidote and calcite.'

Island portage.

Two and a half miles east of Kettle falls there are numerous bands of white quartz exposed in the gneiss. One measured two and a half feet in thickness. Most of the rocks from the Lobstick portage up stream are of a decidedly acid type, but there are bands of the more basic, usually in the form of amphibolite. One of the latter is seen just below the crossing of Niven's line, where the survey ended.

Kettle falls

The glacial phenomena of the Abitibi river up to the Sextant rapid- resemble closely those on the other rivers described. Above this rapid, through the Archæn rocks, the river has a distinct valley, with many sand and gravel terraces along its banks, sometimes rising one above another. These are well seen between the Otter and Long portages where, besides low terraces near the water, usually of small area, there is one at 40 feet and another at 100 feet above the present river level. Almost as soon as the older rocks are reached signs of glaciation appear, with the stossing invariably on the north side. The general course of the striæ along the river is south, but exposures vary from S. 10° E. to S. 30° W., true meridian. On the trail, coming out above the Long portage, there is a steep ridge or "horseback" a quarter

Glacial phenomena.

of a mile long, running N. 20° W., and a low ridge of the same character is crossed near the north end of the Long portage.

Extent of Middle Devonian.

The examination of the rocks on the rivers explored shows that the Middle Devonian system extends from the mouth of the Kwataboahegan river, south to a short distance above the Sextant rapid, and north probably along James bay to the Kapiskau river, and westward for a considerable distance. On the Abitibi river, from the Sextant rapid to the Long portage, the rocks belong to the Laurentian system. Then for a distance of about 8 miles the rocks, in general appearance, resemble the Huronian, but the microscopical examination of the hand specimens points to their possibly belonging to the Grenville series. South of this narrow band the formation is Laurentian, and continues the same up the river beyond the southern boundary of the map, or to within a short distance of the Iroquois falls.

CLIMATE AND GAME.

Climate.

During the months of July and August while working on the Kapiskau and Kwtaboahegan rivers the weather was usually fine with warm days and cool nights. The temperature in the early morning averaged about 50 degrees and in the middle of the day 70 to 80 degrees. Thunderstorms preceded by violent gales were rather frequent. Vegetation along the rivers was very rapid and luxuriant.

Game and fur bearing animals.

Game was not plentiful on the Kapiskau and Kwataboahegan rivers, the few Indians who were there, living wholly on fish and rabbits. The only animals we saw in this district were two bears, three deer, a lynx, and two otters, although the Indians hunt beaver, fox, marten, mink, muskrat and weasel. A few ruffed grouse and an occasional flock of ducks and geese were seen, and the tracks of one or two moose. The Indians report that this animal is steadily moving farther north. Pike, pickerel and whitefish are found in the rivers in limited quantity and the last is caught in the bay along the coast. Sturgeon are caught in the Abitibi river, two of which I saw near Singed Martin creek.

Acknowledgements due.

Mr. Owen O'Sullivan, who accompanied me as assistant, did his work in a most satisfactory manner. I am indebted to him for material assistance in making astronomical observations with the transit, and for a number of photographs, illustrative of the geology and scenery of the country examined, as well as for aid in the general management of the work.

My thanks are due Messrs. Robert Skene, David Armit and other officers of the Hudson's Bay Company for valuable assistance; to the

Rt. Rev. J. A. Newnham, Bishop of Moosonee, for personal kindness and to the Rev. F. Swindlehurst for photographs of the waterfalls on the Missinaibi river, etc.

The following insects were collected chiefly on James bay and the Kapiskau river in July and August, and were identified by Dr. James Fletcher of the Central Experimental Farm.

COLEOPTERA.

Carabus Mœander, Fisch.
Pterostichus orinomum, Leach.
Adalia frigida, Schn.
Lina lapponica, L.
Lina scripta, Fab.
Monohammus scutellatus, Say.
Pissodes strobi, Peck.

LEPIDOPTERA.

Grapta j-album Bd.-Lec.
Lycæna lucia, Kirby.
Pieris oleracea-hiemalis, Harr.
Sphinx gordius, Cram.
Cosmia paleacea, Esp.
Triphosa dubitata, L.

ODONATA.

Aeschna verticalis, Hagen.
Diplax hudsonica, Selys.
Calopteryx Virginica, Drury.

List of plants collected by W. J. Wilson along the shore of James bay and in the valley of the Kapiscau river.

By John Macoun.

The species included in the first column are those collected along the shore of James bay between the mouth of the Moose river and the mouth of the Kapiscau. The second column includes the species collected along the Kapiscau river. Botanical specimens.

Anemone nemorosa, L ..		+
Anemone multifida, DC.	+	+
Anemone Canadensis, L.	+	+
Anemone parviflora, Mx ...		+
Thalictrum dioicum, L.		+

Ranunculus septentrionalis, Poir		+
Caltha palustris, L.	+	
Actæa rubra, Willd	+	+
Arabis hirsuta, Scop		+
Erysimum cheiranthoides, L		+
Sisymbrium humile, Meyer		+
Draba incana, L	+	+
Viola cucullata, Ait		+
Stellaria borealis, Bigel	+	
Alsine humifusa (Rottb.)	+	
Arenaria peploides, L	+	
Astragalus alpinus, L		+
Lathyrus maritimus, Bigel	+	
Lathyrus palustris, L	+	
Vicia Americana, Muhl		+
Prunus Virginiana, L.		+
Neillia opulifolia, Benth & Hook		+
Rubus triflorus, Richards		+
Rubus arcticus var. *grandiflorus*, Ledeb		+
Fragaria Virginiana, Duchesne	+	+
Potentilla anserina, L.	+	+
Potentilla palustris, Scop	+	
Rosa acicularis, Lindl.		+
Amelanchier Canadensis, T. & G		+
Mitella nuda, L.		+
Parnassia parviflora, DC		+
Parnassia Kotzebuei, Cham. & Schlecht		+
Ribes setosum, Lindl	+	
Hippuris maritima, Hellenius		+
Epilobium spicatum, Lam		+
Aralia nudicaulis. L		+
Cicuta maculata, L.		+
Heracleum lanatum, Mx	+	
Cornus Canadensis, L		+
Viburnum pauciflorum, Pylaie		+
Cornus stolonifera, Ex		+
Lonicera involucrata, Banks		+
Lonicera glauca, Hill		+
Linnæa borealis, Gronov.	+	+
Galium boreale, L		+
Erigeron Philadelphicus, L		+
Erigeron hyssopifolius, Mx		+
Antennaria pulcherrima (Hook)		+
Achillæa millefolium, L	+	+
Pyrethrum bipinnatum, L	+	
Artemisia vulgaris, *L.*, var. *Tilesii*, Ledeb	+	
Petasites sagittata, Gray	+	
Arnica Lowii, M. H. M		+
Senecio palustris, Hook	+	
Senecio aureus, L	+	
Senecio Balsamitæ, Muhl		+
Taraxacum alpinum (Koch)	+	
Taraxacum officinale, Weber	+	
Vaccinium Vitis-Idæa, L		+
Vaccinium Canadense, Kalm		+

Arctostaphylos Uva-ursi, Spreng.	+	
Kalmia glauca, Ait.		+
Pyrola rotundifolia, Mx.	+	
Pyrola asarifolia, Mx.		+
Pyrola chlorantha, Swartz		+
Pyrola secunda, L.		+
Moneses uniflora, Gr.		+
Trientalis Americana, Pursh		+
Glaux maritima, L.	+	
Mertensia paniculata, Don.		+
Castilleia septentrionalis, Lindl.		+
Pedicularis Groenlandica, Retz.		+
Rhinanthus Crista-galli, L.	+	+
Pinguicula vulgaris, L.		+
Brunella vulgaris, L.		+
Rumex Britannicus, L.	+	
Polygonum viviparum, L.	+	+
Shepherdia Canadensis, Nutt.	+	
Comandra livida, Rich.	+	
Alnus incana, Willd.	+	
Alnus viridis, DC.		+
Betula glandulosa, Mx.	+	
Populus balsamifera, L.	+	
Salix rostrata, Rich.	+	
Juniperus nana, Willd.	+	
Corallorhiza innata, R. Br.	+	+
Habenaria dilatata, Gray		+
Habenaria obtusata, Rich.		+
Orchis rotundifolia, Pursh		+
Cypripedium acaule, Ait.		+
Cypripedium pubescens, Swartz.		+
Cypripedium passerinum, Rich.		+
Calypso borealis, Salisb.		+
Sisyrinchium angustifolium, Miller		+
Maianthemum Canadense, Desf.		+
Smilacina stellata, Desf.	+	+
Allium Schœnoprasum, Linn.		+
Lilium Philadelphicum, Linn.		+
Tofieldia glutinosa, Willd.		+
Triglochin maritimum, *L.*	+	
Scirpus maritimus, Linn.	+	
Carex maritima, *M*uller	+	
Carex lanuginosa, Michx.		+
Hierochloa borealis, R. & S.	+	
Calamogrostis hyperborea, Lange	+	+
Festuca ovina, Linn.	+	
Hordeum jubatum, Linn.	+	
Elymus mollis, Trin.	+	
Elymus dasystachyon, Trin.		+
Botrychium Lunaria, Swartz.	+	
Botrychium Virginianum, Swartz.		+

GEOLOGY OF THE BRUCE MINES DISTRICT.

Mr. E. D. Ingall.

Work done by Messrs. Ingall and Denis.

At the beginning of June, field work was begun in the Bruce Mines District, Algoma, Ontario. Mr. Theo. Denis accompanied Mr. E. D. Ingall, who had charge of making a study and a detailed map of an area some twenty miles square, embracing a district which is important from an economic standpoint, on account of the attention now being given to its copper deposits, and also from the presence of iron ore. The area comprises the townships of Plummer, Johnson, Tarbutt, Laird, McDonald, Meredith, Aberdeen, Kehoe, McMahon, Chesley add and a portion of the Garden River Indian reserve. The object was to study, as far as conditions allowed, the relation of the mineral deposits to the inclosing rocks and their modes of occurrence; also to verify and correct the geological mapping as given in the atlas accompanying the Geology of Canada of 1863. Mr. E. D. Ingall undertook the careful study of limited mineralized areas, investigating their lithology, the manner of deposition and the exploitation of their mineral deposits in detail, and to Mr. Denis was assigned the work of the mapping of the general distribution of the rocks of the district and the topography required for the construction of a map. As there were no maps of the district available, on a convenient scale, the greater part of the season was devoted to topographical work. All the roads were surveyed with micrometer and railroad compass, some 250 miles being covered. The rock-exposures along these roads were also located, thus affording a good skeleton of the geology, which however, requires additional work to fill in the gaps before completing the map. Towards the end of the season, Mr. Denis joined Mr. Ingall and assisted in carrying out the investigations at the several points which had been chosen for detailed geological work.

The district under consideration, forms part of the typical Huronian area, studied and mapped out by Alex. Murray in the early days of the Geological Survey of Canada. The map, on a scale of eight miles to the inch, in the atlas which accompanies the Geology of Canada, 1863, gives a good idea of the general distribution of the rocks; but as the material for the construction of the map was gathered at a time when the country was bush-covered and travelling through it difficult, it can be easily understood that the geological lines require correction in places, in the light of later observations carried out under more favourable conditions.

General geology.

The sequence of the rocks of the Huronian series, as observed by Murray, together with his descriptions, will be found in the Geology of

Canada, 1863, but since then, some of the members of the series have been the object of more thorough investigation. One of the prominent features of the formation is the 'slate conglomerate,' which has been divided in the Geology of Canada into two members, the lower and the upper. The aggregate thickness of this rock has been estimated by Murray to be over 4,000 feet. It is similar to the 'breccia conglomerate' of the Temiskaming region, which has been the subject of thorough investigation by Dr. Barlow of this department. This is well described in his report on the Temiskaming region. (Ann. Rep. of the Geol. Surv. vol. X. pt. I.) Dr. Barlow believes it to have had a pyroclastic origin. The following is an abstract of his description. 'The rock is composed of a groundmass or matrix in which are embedded pebbles and fragments of biotite granite or granitite, hornblende granite, diabase, diorite, &c. These vary greatly in size from small grains to boulders of fifteen inches in diameter and even larger. They are very unevenly distributed throughout the groundmass, sometimes in aggregates, the individuals being very close together, whereas in other places they are very sparsely disseminated, leaving between them wide interspaces of the groundmass. The granitite fragments are by far the most abundant. This material is usually of a pink colour and coarse in texture. A thin section prepared from one of the pebbles shows the rock to be greatly decomposed and to consist of orthoclase, which predominates, with plagioclase and microcline. The feldspar is much decomposed, consequently turbid and filled with sericite, epidote and calcite; the bi-silicates are almost entirely altered to chlorite. The quartz is of the ordinary granitic variety; it has a somewhat wavy extinction, but does not show other proofs of having undergone great strain. Hornblende and biotite were probably originally present but have been totally altered to chlorite.'

Slate conglomerate.

The other rocks represented by pebbles in the groundmass have also been studied; the diabase fragments are fine-grained and show much decomposition. There are also present fragments of greatly crushed and stretched felspathic quartzite.

The matrix or groundmass in which these pebbles and fragments are embedded was found by Dr. Barlow to consist mainly of granitic debris, the fragments as a rule being simple minerals with angular or irregular outlines, indicating that they were not subjected to the trituration usually shown by constituents of ordinary clastic rocks. The minerals represented, as a rule, are orthoclase, plagioclase, microcline, with chlorite, sericite, epidote and zoisite, as well as magnetite, ilmenite and pyrite; quartz is also present, frequently showing pronounced uneven extinction.

Quartzites.

This breccia conglomerate is underlain by a series of quartzites, felspathic in character, the textures of which vary considerably from very fine grained, in places vitreous quartzites, to coarse grained, almost conglomeratic in appearance. Overlying the breccia conglomerate is another group of quartzites, the lower members of which are also felspatic. This arkose character gradually disappears and the upper members are vitreous non-felspathic quartzites ranging in colour from dark purple to perfectly white, containing in one case the red jasper pebbles which give rise to the red jasper conglomerate.

This series of quartzites overlying the breccia conglomerate has been divided into several individual members by Murray, who has mapped out their distribution with sharp boundaries. These contacts in the field, wherever observed last summer, were however not found to be very well defined, but seem to be more of the nature of a merging of the rocks into one another, the character of the strata changing gradually.

Igneous rocks.

The district is traversed by belts of igneous rocks which differ greatly in importance, varying from quite small areas to others many square miles in extent. The different areas vary considerably also both in mineral constitution and texture. They are mentioned in the 'Geology of Canada,' but are not defined on the map of the Huronian region which accompanies it. As the mineral deposits of the district seem to be largely connected with these rocks, it would be important to delimit them and study them more closely than could be done in the general examination made of the district. As a beginning towards this, some forty thin sections of specimens collected last summer are being made and will be examined as soon as they arrive.

These igneous rocks are referred to in the Geology of Canada as overflows. Although the definite conclusion as to their being so or not cannot be arrived at without more field investigation, yet the evidence gathered so far would certainly in most cases assign to them an intrusive rather than an overflow character.

Ores.

The region has received attention chiefly on account of occurrences of copper ores, although some properties have been prospected for iron ores. The copper occurs in the form of sulphides, the common ore being chalcopyrite. Bornite occurs intermixed with the chalcopyrite in the ore, especially in the surface zone.

Within the area examined, the points at which most work has been done and which were therefore selected for especial studies of the mode of occurrence of the copper ores were The Bruce, Wellington and

Huron Copper Bay, the Rock Lake, the Cameron and the Richardson mines. Besides these, a number of other properties were examined where only surface prospecting had been done.

By far the most extensive developments made are those of the mines in the vicinity of Bruce Mines on the shore of Lake Huron, about thirty-five miles east of Sault Ste. Marie, Ontario. Bruce and Wellington mines.

Although these mines were recently reopened, their history dates back over half a century, work having been commenced in 1846. The mines are situated on a group of veins whose outcroppings, showing first on the shore at a point about a mile east of the dock at Bruce Mines, have been traced for over a mile and a half in a general northwesterly direction to the limit of the workings of the Huron Copper Bay mine.

The veins are unquestionably fissures in an extensive area of 'greenstone.' The final decision as to the exact nature of this igneous mass and its relationship to the surrounding sedimentaries is a matter requiring further work in the field and microscopic examinations of the rock specimens brought in. However, as the result of a preliminary examination of a couple of thin sections by Dr. A. E. Barlow, petrographer to the department, the rock would appear to be uralite diabase. A number of dykes of a more compact diabase cut both the general mass of the older rock and the series of veins.

The area of diabase above mentioned shows a width in a northerly and southerly line of about a mile from the shore line to where the sedimentary rocks of the series first appear. No boundaries were located to its extension east and west, as it passed outside of the area under study. The large islands closing in the mouth of Bruce Mines bay are also 'greenstone,' but the shores of the western end of the bay being drift covered it could not be determined whether or not they connect with the main area of the mainland to the north. There seems to be a possibility that a belt of quartzite may intervene which has determined the erosion of the hollow now forming the bay. Islands of greenstone.

On the northern side this greenstone is followed by quartzite with which is associated a thin bed of impure limestone. Near the westerly workings of the Huron Copper Bay mine this limestone bed seems to be cut off abruptly by the greenstone, although the actual contact must be in the low ground intervening between the exposed surfaces af the two rocks. The limestone can be traced pretty continuously in an easterly direction to the edge of the area examined.

Only at one place however is the actual contact exposed, a wide stretch of drift intervening as a rule. At the point above mentioned the contact seems to be distinctly an intrusive one, tongues of the greenstone cutting the limestone. Much more precise exploration would be required however to decide whether these represented tongues of a dyke cutting both rocks, and younger than both or whether thereby the intrusive nature of the whole mass is to be considered proved. Passing easterly from this point, which is near the road between the village and the Canadian Pacific Railway station, it is found that a comparatively thin bed of red and dark brown quartzites intervenes between the greenstone and the limestone, the latter showing as a little ridge. Between this ridge and the rock exposures of slate conglomerate along the railroad, about half a mile to the north, the section is practically all drift-covered in the vicinity of the road. Search would have to be made therefore in the bush-covered lands east and west of this point for more continuous exposures in order to work out the actual succession of the sedimentaries lying to the north of the igneous area in which the mines lie.

Without attempting to settle these yet outstanding questions the main features of the economic deposits at this point may be summed up as presenting a series of large fissure veins cutting an extensive mass of 'greenstone,' the latter being bounded on the south by the waters of Lake Huron and on the north by the quartzites, limestone and slate conglomerates of the Huronian series.

In an easterly direction the southern limit of the greenstone is shown toward the bottom of the eastern lobe of Bruce Mines bay, where the white quartzite of Murray's map comes in. The quartzite is continuous along the eastern shore of the Bay, where, however, it is seen to be cut by numerous basic dykes.

The sedimentaries of the series are seen everywhere in the vicinity of this group of mines to dip at low angles toward the north. Along the shore of Lake Huron, however, westerly from Bruce Mines bay, the dip is southerly, exhibiting thus the other side of the anticlinal fold described and mapped by Murray.

Nature of veins worked.

The veins worked in this group of mines consist, as previously stated, of fissures. They carry the copper in the form of different sulphides, chiefly chalcopyrite, in a gangue of quartz. At places the gangue is partly dolomitic, but the former mineral is very largely predominant as evidenced by the material of the waste piles around the workings. Near their outcrops, the veins are said to have carried a higher percentage

of copper than below, owing to the presence of bornite and other rich sulphides of the metal. The presence of these minerals is probably due, as would elsewhere appear, to secondary enrichment.

Old mines described.

A preliminary examination of the lower levels of the Wellington and Huron Copper Bay workings showed chalcopyrite with some pyrite disseminated through a gangue of white quartz. In the Wellington and Huron Copper Bay mines, the veins have been worked out to great widths, excavations often reaching widths of 25 to 30 feet. Of course there are many places where the veins narrowed down to not more than four feet in thickness, but ten feet might perhaps be accepted as an average of the thickness all the way through. At the old Bruce mine the veins are seen to be narrower and in the main workings would not average possibly more than five feet.

The total length attained in the Bruce workings would measure about 2,000 feet, whilst the combined length of the Wellington and Huron Copper Bay mines would measure nearly 2,500 feet. The workings at the Bruce attained depths of 250 to over 300 feet and at the Wellington the average of the depth attained in the workings would be about the same although Bray's shaft was put down to about 1,060 feet. The area of the veins stoped out, as shown on the old plans, would measure approximately as follows, viz. :—At the Bruce Mine about 225,000 square feet which, assuming a depth of 300 feet for the mine, would represent a length of, say 750 feet of vein excavated. At the Wellington, etc., a total measurement is shown of about 600,000 square feet, which would represent for a depth of say 300 feet, an equivalent in length of 2,000 feet. In both cases, it must be born in mind that these represent workings on two main veins close together and parallel to each other as worked in these two mines. In the Wellington &c., mines, these were known as the New Lode and Fire Lode. They paralleled each other for about 1,300 feet, but joined together to form a single vein at the east and western ends of the workings.

The westerly part of the Bruce workings are situated on the main lode and its branches for about 1,300 feet, whilst east of this, for about 600 feet, the chief excavations are on two veins, known as the Trial and Dodge veins. A good deal of prospecting work was done on minor veins and branches in the vicinity of these two chief mines, and also in veins which outcrop in the 4,000 feet of distance intervening between the Bruce and Wellington workings, but much more development will need to be done before the question as to the practical continuity of the series of fissures and their profitable nature can be

settled. An excavation called Taylor's shaft, from which it was said some test drifts were run, was sunk about midway of the distance between the two mines, but no details are available as to the results attained. The particulars given above refer to the work done during the first period of the history of these mines by the West Canada Copper Company and its predecessors. This period ended with the final cessation of work in 1876. When this company was working at its strongest it employed as many as 380 men, and for the period of years from 1858 to 1875 produced about 37,378 long tons of concentrates having a total content of nearly 7,500 long tons of copper, valued at over $2,900,000. The average price received for the copper during this whole period of eighteen years would thus be somewhat over 17 cents per pound. Since 1858, however, the price of this metal has fallen off considerably. In that year the company obtained an average of 21 cents per pound for its copper, whereas the figures for 1875 show an average value for their product of less than 16 cents per pound. When the present company bought the mines a few years ago it reopened them and some further work was done, of which, however, we have as yet no complete data. At present nothing is being done other than to keep the plant and mines in order. In connection with the operations of the present company, the mines have been fully re-equipped with modern machinery for mining and ore-dressing, the mill having a capacity of 400 tons per day. As it is intended to give full particulars of this important group of mines in the complete report to follow later, nothing further need be stated here.

West Canada Copper Co'y.

The final failure of the first attempt to work these mines seems to have been due to a variety of causes, many of which have ceased to be operative with the progress of opening up of the district, and it becomes a question as to whether successful work could not again be carried on with careful management and the improved plant and methods available.

Rock Lake mine.

The Rock Lake mine is situated some fourteen miles north of Bruce Mines village. It is equipped with a complete mining plant, including hoists, air compressor, drills, etc., and with a mill with a capacity of 100 to 125 tons per 24 hours. The latter is situated on the shore of Rock lake, nearly two miles west from the main shaft with which it is connected by a tramway. Transportation is afforded from the mill by the Bruce Mines and Algoma Railroad, which connects with the Canadian Pacific Railway at Bruce Mines station, with an extension to the lake shore at Bruce Mines village.

The ore consists of chalcopyrite with some bornite, &c., in a gangue consisting mostly of white quartz with which is intermixed at places

a good deal of ankerite, the ochreous decomposition product of the latter constituting a marked feature of the outcroppings at places. The developments made are situated along what appears to be a shattered zone at the contact of the red quartzite and the 'upper slate conglomerate' of Murray. The quartzite proper extends for a width across the strike of about a mile southerly, and the 'slate conglomerate,' etc., about an equal distance northerly. The workings are situated along a narrow subsidiary valley about half way up and running lengthwise of the hills of slate conglomerate flanked with quartzite which rise to a height of some 400 or 500 feet above the level of Rock Lake. In the vicinity of the mine buildings and main workings the width of the zone of shattered quartzite exposed is from 500 to 700 feet. Passing northward, this is followed by a belt of green schistose rock, showing a width of outcrop of about 400 feet. For about 400 feet further there are no rock exposures until the foot of the northern ridge is reached, where the typical 'slate conglomerate' emerges abruptly from beneath the cover. This belt exhibits the characteristic features elsewhere found of well rounded pink boulders and pebbles of granitic rock, &c., scattered throughout a dark greenish-grey matrix of slaty appearance. Rock Lake mine.

The veins worked in the main shaft and connected workings are in the schistose belt. Other less extensive workings to the south of these are in veins in the shattered quartzite zone. It seems probable that the schistose belt above mentioned represents merely a portion of the 'slate conglomerate' in which schistosity has been developed by the disturbing force that at the same time produced the series of veins and shattered the adjacent quartzite.

The general dip of the formation is southerly about 25° although near the mill there is evidence of a somewhat steeper dip in the flanking quartzite, followed in ascending the hill northward by a flat anticlinal and synclinal fold before reaching the main ridge of slate conglomerate.

A comparatively small dyke of greenstone, measuring from 100 to 150 feet in width runs with a general north-westerly strike roughly parallel with the general trend of the veins. It lies about 100 feet to the south of the main shaft, and at the west end passes close to the north side of the mill. The developments made up to October, 1902, consisted of the main shaft and workings together with a considerable amount of surface development for a distance of some 1,500 feet east and a number of test pits, &c., along the same general direction westerly for about a mile and a-half. At the most of these points ore has been

exposed showing chalcopyrite disseminated through a quartz or quartz and ankerite gangue. Of the relationships of the veins to those worked in the main shaft, nothing could be definitely stated without still further detailed mapping and study, owing to the disturbed condition of the formation previously alluded to.

The main shaft, which is practically vertical, at the date of the last visit made had attained a depth of 400 feet. From it, levels had been driven east and west at depths of 100 feet and 200 feet, testing the vein for a length of nearly 600 feet. At the bottom of the shaft a small crosscut to the south reached the main vein at about 35 feet, which had been followed west in a drift for about 30 feet. The ore mined was being taken from above the second level, the stopes exhibiting a width of about 20 feet.

Apart from the small dyke already mentioned, the only intrusive rocks anywhere in the vicinity are represented by two considerable ranges of greenstone traversing the sedimentaries at distances of half a mile north and south of the mine respectively and with a general trend parallel to that of the formation.

Cameron mine.

About two and a half miles north-east from Desbarats station on the Canadian Pacific Railway (Algoma branch) is the mine known as the Cameron or Stobie. At this place a fissure vein is seen cutting a ridge of red quartzite. On this vein a shaft has been sunk some 150 feet in depth from which, at 100 feet down, have been run drifts east and west totalling in length about 150 feet. The outcropping of the vein to the east of the shaft is not visible, being covered, but it has been stripped west of the shaft for a distance of 150 feet, where it runs under the deep soil of the adjacent farming land of the valley. Seventeen hundred feet further west on the rocky ridges opposite the mine, small surface workings have also shown the existence of ore. These are roughly on the strike of the Cameron mine vein, but whether they are to be taken as representing its actual extension or not is doubtful. The outcroppings near the shaft show a composite vein of about four feet in width, the ore being chalcopyrite in a gangue of white quartz. Some specimens show plainly surface change of the chalcopyrite to bornite. The vein in the workings shows a dip of 75° to the south and a width at places of about 12 feet made up of subordinate branches with 'horses' of quartzite.

Following the quartzite ridge southerly for about 700 feet, several small greenstone dykes cut across the quartzite in a direction roughly parallel to that of the vein. About 600 feet north-easterly from the

shaft a coarser greenstone outcrops in one or two places, about on the run of a belt of the same rock visible in the ridges on the other side of the valley, where it shows a width of at least 125 feet. If this belt is actually continuous underneath the soil of the valley, it would thus pass about 400 feet north of the vein and with a course generally parallel to it, whilst the smaller dykes before mentioned would probably represent tongues connected with it.

The mine is equipped with power drills, hoist and pumps suitable for carrying on development work.

Richardson mine.

The workings known as the Richardson mine are situated about two miles and a half north of Desbarats village near the south-east end of Desbarats lake. These consist of a small prospecting shaft and a number of shallow pits and trenches extending over a distance of about three-quarters of a mile along the strike of a series of greenstone dykes which cut the jasper conglomerate of the sedimentary series. The evidences of the intrusive nature of the greenstone are here very marked, long narrow strips and lenses of the jasper conglomerate being included in the igneous mass. Some of the mining work done here is altogether in the greenstone, as in the case of the before-mentioned shaft. Here, as so frequently observable elsewhere in the district, the rock is much decomposed and the resulting ochreous material has stained it, giving a very tempting ferruginous appearance, whilst in the jointing, etc., it has at times consolidated to form fairly good hematite ore.

Most of the trenching and test-pitting east of this shaft has evidently been done with a view to the examination of the contacts along these inclusions of jasper conglomerate. At all the points uncovered, the ochreous material and stain were much in evidence and at some points a little chalcopyrite with malachite stain shew the presence of copper in small quantity.

Stobie Iron mine.

The Stobie iron mine is amongst the older discoveries of the district. It is situated near the western end of Gordon lake. The openings made consist of a rock-cut in a ridge of white quartzite, run in to catch a small vein of hematite averaging about five feet in width. In the face of the bluff the vein in going upward splits into two branches, each about three feet thick. On the bare rock-surface of the top of the ridge it seems to be represented only by a number of small stringers of ore. From the end of the open cut, a tunnel has been run in, but this is now closed by a cave in at a distance of about 30 feet from the mouth.

It is said that several thousand tons of good ore were shipped from this opening many years ago, a statement which is borne out by the existence of a stope above the tunnel, measuring about 80 feet in length by 50 feet in height, and having a width varying from 3 to 8 feet.

The quartzite has a strike at this point of N. 55° W., and dips about 45° to the south at the bottom of the ridge, curving over, however, till the dip flattens out to about 20° on top. About a quarter of a mile to the north, an east and west ridge of greenstone rises up, representing evidently an intrusion through the quartzites.

At a number of other points in the district exploratory work has been done on ferruginous outcroppings of a somewhat similar nature, either in the greenstone or in the inclosing rocks near the contact. These places show all grades of material from ochreous staineded rock to the consolidated ocherous product constituting specimens of good hematite. At none of the points visited, however, had any large bodies of iron ore been proved to exist.

The Sudbury Mining District.

Dr. Alfred E. Barlow.

Work by Dr. Barlow.

From the first of the year until the beginning of field operations on June 6, Dr. Barlow was engaged in making detailed petrographical examinations of rock specimens collected by some members of the staff as well as of the large suite of type specimens taken as illustrative of the various formations met with in the geological examination of the Sudbury mining district during the preceding season. In addition to these, determinations and descriptions were furuished of some of the specimens collected by Messrs. W. F. Robertson and H. Carmichael of the British Columbia Department of Mines.

When this work was finished, Dr. Barlow left for Sudbury with instrnctions to complete as far as possible the general geology in the vicinity of the southern nickel belt, and also to do such detailed work in connection with the Canadian Copper Company's mines as would serve to illustrate on a map of comparatively large scale, the occurrence of these justly celebrated deposits of nickel and copper ores. It is now intended to publish two maps engraved on copper, showing in a general way, the geographical distribution of the various rock-types and formations encountered. These, in accordance with our usage, will be called the 'Victoria Mines Map' and the 'Sudbury Map.' The details of the work in the vicinity of the Canadian Copper Company's

Map.

mines at Copper Cliff, will be shown in two sheets, each on a scale of 400 feet to an inch, extending from the vicinity of Kelly lake and the Evans mine northward to the Lady Violet mine and the Manitoulin and North Shore Railway. Another but smaller sheet on the same scale will exhibit the geological relations of the deposits known as the Elsie and Murray mines. Mr. O. E. Leroy, M. Sc., of McGill University, assisted me in both the geology and topography. Work by O. E. Leroy.

The geological history of the Sudbury mining district, as revealed by the rocks now exposed at the surface, evidences volcanic action on a large scale, accompanied to a certain extent, and followed largely by the deposition of ordinary aqueous sediments in a shallow ocean. The rocks represent the Huronian period, and are the oldest known clastics with which geologists are at present familiar. Classified petrographically they are as follows:—

Rock types.

1. Quartzite.
2. Tuffs.
3. Breccia or agglomerate.
4. Greenstone.
5. Gneiss (micropegmatite).
6. Granite.
7. Olivine diabase.

1. *Quartzite.*

Macroscopically these rocks are massive, though distinctly stratified, of a pale gray, reddish, yellowish gray, or greenish gray colour. They are intimately associated with, and often inter-bedded with the tuffs and breccias, so that it is frequently impossible to separate the two in mapping them. Macroscopic characters of quartzite.

Under the microscope the thin sections exhibit a rock made up chiefly of quartz, with a somewhat smaller proportion of feldspar, most of which is unstriated, and therefore presumably orthoclase. Occasional grains of microcline were noticed showing, the characteristic fine 'cross-hatched' twinning or 'fenster' structure. Much of the feldspar is decomposed into muscovite (sericite) occurring in irregular pale yellowish or colourless scales and plates and which, together with fragments of undecomposed feldspar and finely divided quartz, make up a matrix in which the larger individuals of quartz are embedded. The structure of the rock is for the most part interlocking, but some speci- Mineralogical composition of quartzite.

mens show distinct clastic structure, while in most the resemblance to well authenticated recrystallized clastics is such as can hardly be mistaken. A little chlorite, biotite, calcite and leucoxene are also usually present. These quartzites are at the summit of the clastic series of the district. To the north-west of Sudbury they occur in very massive beds, the lines of stratification being either very indistinct or altogether absent. A careful examination of the whole belt shows that it forms a synclinal basin resting upon the steeply dipping tuffs or ash rocks which underlie the greater part of the town of Sudbury. Nearly all of the exposures of the clastic rocks in the south-eastern part of the township of McKim and the whole of the township of Neelon belong to the quartzite series. On Ramsay lake they overlie the breccia or agglomerate exposed along the northern shores of the lake.

Distribution and stratigraphical position of quartzite.

2. *Tuffs.*

Tuffs or greywackes.

The rocks thus named, and concerning whose volcanic origin there is now but little doubt, have hitherto been often described as phyllites, mica-schists, felsites and greywackes. They evidently represent the consolidation of what was originally volcanic ashes, being one result of the volcanic action to which is due the presence at the surface of the great belts of greenstone and micropegmatite. These rocks are usually of a dark gray, purplish brown, or greenish-gray colour. They are often evenly and very distinctly banded in varying shades of gray, Jointing is very frequent and also slaty cleavage. They are often faulted and shattered, and in the vicinity of the various greenstone masses are penetrated and altered by irregular tongues and masses of the basic igneous material. They are frequently porphyritic and usually the phenocrysts are small, very thickly disseminated and of a very pale greyish or whitish colour. For this reason the rock has been referred to in the field as 'rice rock.' These phenocrysts were probably andalusite, but the skeleton-forms are now occupied by a confused aggregate of minute sericite scales and quartz. Other exposures show small yellowish brown spots made up of rutile, while others again show irregular phenocrysts of hornblende, now wholly replaced by chlorite. Thin sections examined under the microscope reveal a rock which has undergone rather extensive decomposition. It is usually made up very largely of feldspar with a smaller proportion of quartz in small angular or slightly rounded fragments. These are surrounded by a network of sericite and chlorite scales, together with a considerable amount of opaque iron ore. The larger individuals at least have evidently been ilmenite, but are now almost completely altered to leucoxene. The darker bands are made up of

Colour and structural features.

Mineralogical composition.

more thickly disseminated dust-like particles of iron ore, much of which at least is ilmenite.

3. Breccia or Agglomerate.

Perhaps the most interesting type in the district is a very distinct breccia made up of volcanic ejectamenta in the form of glass fragments of all shapes and sizes associated with some crystals or crystal fragments. This rock was very fully described by Professor G. H. Williams.* It is closely related to the other breccias of the district, which although showing rather clearly their close genetic relations with the widespread and long-continued volcanism are nevertheless largely made up of material which shows unmistakable evidence of water action. There are, therefore, the several varieties exhibiting gradations from the massive structureless types, the direct result of explosive action, to some which have been very evidently modified and rearranged by water. Such rocks are as a rule of a dark gray colour with the disseminated angular, subangular, or rounded fragments chiefly of quartz, granite, diorite, etc. Thin sections exhibit a rock made up of fragments chiefly of quartz, but also of orthoclase, plagioclase and microperthite. The most abundant composite fragments are granitite, composed mainly of microperthite and quartz together with a little biotite. All of the larger individuals are imbedded in a matrix made up of much finer pieces of quartz and feldspar, together with biotite, sericite and a pale green chlorite. Occasional grains of pyrite and also some of ilmenite occur. These breccias lie at the base of the series, usually passing gradually upward into the finer-grained and usually banded tuffs above. The vitrophyre tuff or volcanic breccia, described by the late Prof. Williams, is well exposed in the north-eastern part of both the Victoria Mines and Sudbury maps, extending from Vermilion to Whitson lake. Excellent exposures of the last mentioned breccia may be seen along the line of the Canadian Pacific Railway, immediately east of Sudbury and in the vicinity of the north shore of Ramsay lake.

Description by Prof. Williams.

Composition of breccia.

Stratigraphical position.

Distribution

These various rock-formations in the district, must in my opinion, be regarded as all belonging to one geological system. In the region to the south-west, similar strata have been referred to the Huronian by the earlier Canadian geologists, and in the present state of our knowledge I see no good reason to abandon this view Of course, as yet, no particular evidence has been secured or reason advanced, why these rocks should not be regarded as very early or non-fossiliferous Cambrian, which by reason of their proximity to large masses of plutonic igneous material, have been subjected to more or less disturbance and alteration.

Formations belong to one system.

* In report by Dr. Bell, Annual Report Geol. Surv. Can., vol V., (N.S.) 1890–91, p. 75, F.

On the other hand, there is very little to justify the attempt at a separation into Huronian and Cambrian, as was done on the map published by the Canadian Geological Survey in 1891, since it has now been very certainly ascertained that no pronounced geological break or hiatus, such as is present in other districts at the base of the Cambrian, occurs anywhere in this region. The succession from the felspathic sandstones, quartzites and slates of the Huronian into the black slates and tufaceous sandstones, classified as Cambrian, shows a quite uninterrupted transition with perfect conformity between the component beds or strata. Their disassociation as Huronian and Cambrian, respectively, was at the first based partly on the resemblance of these black slates to similar rocks in the Animikie of the Lake Superior district and their comparatively unaltered character. The description of this large area on the map of the Sudbury mining district was only intended to be provisional, and the precaution was taken of expressing the uncertainty of the correlation by placing the query mark in the legend accompanying the map. As usually happens, however, in such cases, this mark of doubt was removed in subsequent official maps and reports published elsewhere apparently through ignorance, without any further attempt at fuller and more critical examination and study.

4. *Greenstone.*

Three main types of greenstone.

Under this convenient field term are included certain basic igneous rocks, many of which have undergone extensive metamorphism, so that in certain cases even the closest scrutiny under the microscope, fails to reveal the original form. Microscopical examination has, however, shown the existence of three main types, although all possible transitions between these are represented in the region :

(*a.*) Norite.
(*b.*) Diorite.
(*c.*) Amphibolite.

Norite.

The least altered phase of these rocks is represented by what may be referred to as a norite. The late Prof. Williams described the rock under the name of 'quartz-hypersthene-gabbro with accessory biotite,' but from the descriptions of the field relations furnished to him, he failed to realize that he was really examining a very fresh representative of the country rock of the nickel and copper-bearing sulphides.

Mineralogical composition of norite.

The microscopical examination shows the rock to be an eruptive of rather exceptional character and interest. It belongs to the general family of gabbros but with distinct and at times well marked traces

of diabasic or ophitic structure. The abundance, and at times, preponderance of hypersthene or enstatite shows its close affinity with the norite, while what is very exceptional, the occurrence of an abundance of quartz, as an original constituent was noticed. In fact many specimens could be secured which would contain as much quartz as an ordinary granite. In some instances, noticeably at the Copper Cliff mines, a large quantity of micro-pegmatite or granophyre is present, the felspathic constituent of this graphic intergrowth being plagioclase. Exposures show a massive medium to coarse-grained dark greenish or brownish rock which is almost black in colour on freshly broken surfaces. Scales of deep brown biotite are usually conspicuous, while the quartz is perhaps equally so in very characteristic sapphire blue or purplish grains, the colour which is so often seen in the phenocrysts of quartz, porphyries. The presence of this sapphire-blue quartz often serves to identify the rock even when it has undergone very advanced alteration, as is the case with most of the outcrops of greenstone in the township of Denison. The orthorhombic pyroxene, either hypersthene or enstatite, which is often idiomorphic was the first of the essential minerals to crystallize. The hypersthene is strongly pleochroic, rose red to nearly colourless; the enstatite on the other hand has little or no colour or pleochroism and very few inclusions. The rhombic pyroxene is very subject to decomposition so that in most cases perhaps, areas of this mineral are replaced by an aggregate of pale green brilliantly polarizing fibrous or scaly serpentine (bastite). This alteration is often accompanied by the separation of minute grains of magnetite. In most cases even the fresh individuals of hypersthene are bordered by a compact strongly pleochroic green hornblende which is doubtless an original constituent. This primary hornblende likewise forms borders on areas showing the complete bastitic alteration. In addition to this there is undoubted secondary hornblende resulting from the alteration, first of the bastite into actinolite and this in turn to the ordinary type of green hornblende. The plagioclase is usually in broadly twinned, stout lath-shaped or tabular crystals, whose frequent interlacing arrangement produces the characteristic rude ophitic structure. Separations by means of Thoulet's heavy solution as well as the extinction angles show that this plagioclase is labradorite. The presence of innumerable brown dust-like inclusions, presumably of ilmenite, gives to the felspar its prevailing dark colour. The monoclinic pyroxene occurs in large irregularly bounded grains. Biotite is an almost invariable constituent and is usually rather abundant and of undoubtedly primary orign. Apatite, magnetite, which is usually highly titaniferous, zircon, and occasionally grains of pyrite are present.

(*b*). Diorite.

Gabbro-diorite.

The least altered phase of the rocks with which the ore bodies are associated is what the late Prof. G. H. Williams calls a gabbro-diorite, that is a diorite which gives unmistakable evidences in the hornblende of its derivation from pyroxene originally present. Mineralogically, this rock as now represented by the thin sections examined, is composed essentially of plagioclase and hornblende. This rock contains, as a rule, only disseminations of the sulphides usually worked. It shows plagioclase in comparatively large amounts. This is evidently labradorite. It usually has undergone rather advanced saussuritization but many individuals are still sufficiently fresh to permit of their identification by means of the extinction angles. The resulting products of alteration are mainly sericite, epidote and zoisite.

Composition.

The hornblende shows the pale interiors with the deeper coloured borders so characteristic of uralite. Biotite is almost invariably present and usually in large amount, often forming intricate parallel intergrowths with the hornblende. It frequently shows decomposition to chlorite. Ilmenite and highly titaniferous magnetite are the prevailing iron ores and these are present often in comparatively large amount. Most of the individuals are surrounded by opaque grayish leucoxene or the more normal sphene resulting from their alteration. The pyrrhotite and chalcopyrite occur as irregular skeleton or sponge-like masses chiefly associated with and imbedded in the coloured constituents. Quartz is almost invariably present, often in comparatively large amount, filling up the allotriomorphic interspaces left by the crystallization of the other constituents. It is not secondary but an integral part of the same magma out of which the other minerals have been formed. Apatite is often abundant, usually in small acicular prismatic forms. An increase in basicity is often accompanied by intense jointing and shearing action with frequent penetration and

Amphibolite

infiltration by vein quartz and calcite. Much of the original holocrystalline and granitoid structure is lost and replaced by a foliated texture marked by the parallel disposition of fibrous hornblende or actinolite and the pulling out or granulation of the plagioclase. The composition of the resulting amphibolite is essentially similar, but with prevailing less plagioclase and quartz, and more of the coloured constituents. The quartz is often in the small bluish or purplish grains so characteristic of the phenocrysts of the quartz porphyries of the Rainy Lake and Yukon districts. Jointing structure is very prevalent, and this structure is so well and abundantly developed that it is almost impossible to secure good hand specimens without the sacrifice of a large amount of material. The schistose structure is also extensively developed and all gradations may frequently be observed in the same

rock exposure, from the massive gabbro-diorite through diorite schist, hornblende schist or amphibolite to chlorite schist. The effect of pressure is much more pronounced and usual in the basic phases of the rock and an amphibolite is the result. An increase in these processes of shearing accompanied by vein action, favours the abundant development of chlorite at the expense of both the hornblende and biotite and the production of a highly chloritic actinolite schist.

Nickel bearing rock.

The nickel-bearing rocks include not only the norites, but some of the gabbro-diorites, which may be altered and differentiated forms of the norite and probably some of the more highly decomposed and schistose basic eruptives. In the vicinity of Copper Cliff and thence northward to the old Dominion mine, it is possible to separate certain schistose basic eruptives, chiefly diorites and amphibolites, from the nickel-bearing eruptive or norite, the latter being of decidedly later age, but to the south-west, where the alteration is extreme, as in the township of Denison, it has been found impossible to do so in all cases. More detailed work might effect such a separation, for it is certain that all of the various basic rock types exist, but they are so intimately associated that it has been found impossible to effect a separation over the whole area. In addition, however, this greenstone portion, or nickel-bearing eruptive proper, passes northward into a more acid rock of granitic composition, with usually well marked gneissoid structure. The rock has usually been referred to as a micro-pegmatite. There is no sharp line of demarcation between. The change though gradual is usually sharp enough to enable a boundary to be placed between the two types with tolerable accuracy. Outcrops of this rock are evenly banded or foliated with a distinct strike and dip, often show distinct or porphyritic structure, weather a pale reddish or grayish colour and are frequently intersected by irregular and often intricate vein-like masses of quartz of pegmatitic origin. On freshly exposed surfaces they are dark coloured with often reddish or yellowish phenocrysts. Orthoclase is apparently present in considerable amount but plagioclasse (one near the acid end of the series, probably oligoclase or oligoclase-andesine) is more abundant. Biotite is the prevailing ferro-magnesian mineral and much of it is often 'bleached' and altered to chlorite. In occasional instances the whole of it is thus altered giving to it the prevailing dark colour on fresh surfaces. The transition types between these and the greenstones show a varying proportion of hornblende, which in general diminishes in going northward, although certain bands of relatively greater basicity show an appreciable amount of this mineral, even at a considerable distance from the line of junction. One of the most noteworthy points in connection with these gneisses

Micropegmatite.

Composition.

is the prevalence of micropegmatite or granophyre, and also the fact that plagioclase and quartz are the component minerals. This micropegmatite, together with the bisilicate material, chiefly biotite or chlorite, and sometimes hornblende and accessory epidote, ilmenite and sphene, form a groundmass in which comparatively large phenocrysts of feldspar, chiefly plagioclase but sometimes also orthoclase and microperthite, are embedded. The feldspar individuals often form nuclei around which the granophyre is developed.

Granite.

Younger granite.

It has been customary of late years to speak of certain areas of acid intrusives occurring in intimate association with the nickel-bearing eruptives as the 'younger granites.' There are two varieties of this granite evidently of the same age. One variety which makes up the large area is a very decided 'augen' granitite-gneiss. In places, it seems to pass gradually into the second variety, a finer or more even-grained granitite with ill-defined or no foliation. This coarse or 'augen' granitite-gneiss makes up a well marked bathylith which forms a border along the southern side, of the main or southern nickel belt. Hand specimens usually show a very beautiful and typical coarse flesh red 'augen' granite-gneiss.

Composition.

Under the microscope, the thin section shows the rock to be made up chiefly of microcline, orthoclase, albite, oligoclase, biotite and quartz with epidote, sphene and apatite as accessory minerals and calcite, epidote, zoisite, sericite and chlorite as secondary products of decomposition. The orthoclase and microcline sometimes occur free; but for the most part are intergrown with the albite, forming both microcline, and orthoclase, microperthite. The quartz is the usual granitic variety, frequently showing intense strain shadows and sometimes granulated into a fine interlocking mosaic. The feldspars of the rock, although like the quartz often much cracked, broken and granulated, are comparatively fresh. Reddish-brown iron oxide has spread through the cracks, giving a cloudy or stained appearance to many of the grains. Much of the oligoclase has undergone considerable saussuritization, the resulting products being epidote, zoisite and sericite. It is usually stained a deep reddish-brown colour. The biotite is usually 'bleached,' and has often undergone more or less complete chloritization. The 'augen' are usually made up of a comparatively coarse-grained aggregate or microperthite or microcline and quartz. More rarely it is a single crystal of felspar, never with well-defined crystal boundaries.

The finer-grained variety of granite is characteristic of two areas. The smaller one is situated immediately east of the Lady Violet mine and extends a little north of the Manitoulin and North Shore Railway on the boundary between McKim and Snider townships. The other larger area extends from the main line of the Canadian Pacific Railway, a little south-east of the Murray mine, north-east, nearly to the Little Stobie mine in the township of Blezard. A microscopical examination of the thin section shows an aggregate of quartz, orthoclase, plagioclase, biotite, hornblende, magnetite and zircon. The rock has evidently been subjected to great crushing. The structure is by no means uniform, but larger fragments are imbedded in a finer-grained mosaic, which have resulted in great part from their peripheral granulation. The magnetite is highly titaniferous, as it is often surrounded by borders of leucoxene or the more normal sphene.

Two varieties of granite.

Olivine Diabase.

The rock thus named, characteristic of what has been called the later dykes, is very uniform in mineralogical composition and structure. Hand specimens show a rock which is dark gray, greenish gray to almost black, with spheroidal rusty weathering which is very characteristic. In many instances, exposures exhibit a rude basaltic structure and are frequently porphyritic with phenocrysts of yellowish or greenish labradorite, often an inch or even more in diameter. The alteration of these phenocrysts produces the mineral 'Huronite,' so named by Thomson. These dykes possess well marked selvages of fine-grained, occasionally glassy material (tachylite) and present every gradation between basalt and diabase. The thin sections of the fairly coarse rock show a remarkably fresh olivine-diabase, made up chiefly of plagioclase, augite and olivine. The plagioclase is the principal constituent and is generally quite fresh and glassy, although occasionally somewhat turbid as a result of incipient decomposition. Being the earliest constituent to crystallize, it is in idiomorphic well-twinned, tabular or lath-shaped crystals, which have a marked ophitic arrangement. The extinction angles clearly indicate labradorite. The twinning is according to the albite law, but a combination of the albite and pericline law is very common. Occasional individuals exhibit twinning according to the rarer Baveno law. The augite shows a very irregular or jagged outline with characteristic imperfect or interrupted cleavages. It is reddish-brown to violet in colour, and very distinctly pleochroic. The olivine occurs in more or less rounded pale yellow grains and sometimes fills in the spaces between the feldspar crystals. It is remarkably fresh but occasionally shows decomposition to a deep

Olivine diabase dykes.

Composition.

green compact serpentine (antigorite ?). Apatite is very abundant in the usual acicular prismatic forms, and the opaque constituent is probably ilmenite. Some of the thin sections are very instructive, especially as regards the order of crystallization of the various mineral constituents. Apatite was certainly the first to crystallize, as it occurs in sharp, well defined elongated prisms which are embedded in or pierce the other constituents. The labradorite has, in most cases at least, crystallized before the augite, but its relation to the olivine is not quite so distinct. In some cases the olivine has the rounded outline it usually assumes when its crystallization is not interfered with, but often it may be found occupying the triangular interspaces between the feldspar laths, or sharply moulded upon them. It appears, therefore, that the period of crystallization of the olivine, certainly overlapped that of the labradorite, although in general the olivine is distinctly later. Most of the ilmenite likewise is earlier than the plagioclase, but occasional individuals contain crystals of olivine and plagioclase, showing that some of the ilmenite formed after the olivine and plagioclase.

Age of dykes.

These dykes of olivine diabase are distinctly later in age than the rest of the associated rock. They cut the greenstones and associated micropegmatite as well as the ore bodies themselves. They likewise cut the tuffs, breccias and quartzites, although one dyke was noticed which did not reach the summit of the quartzites, but was cooled against the upper beds. Their occurrence and the mineralogical composition of some of them in the neighbourhood of the Copper Cliff mine certainly very strongly suggests that they represent differentiated portions of the ordinary norite magma, representing the dying efforts of the very pronounced and long continued volcanism. For the most part they have a fairly constant direction, but present frequent broad curves and occasional faults. Two of the largest dykes met with, vary in width from 150 to 200 feet, and were traced with practically unbroken continuity from the north-west corner of McKim township south-east to Ramsay lake. There is no local enrichment whatever of the ore bodies in the vicinity of the dykes as has frequently been surmized. The influence occasioned by their passage in these ore bodies is extremely local and very insignificant. In the vicinity of the Copper Cliff and Murray mines and the area intervening, many of the dykes have been encountered and it has been found possible over this limited area to accurately determine and map their dimensions and direction, and although the prevailing direction is perhaps north-west and south-east, many of them occupy fissures with courses very widely divergent.

Width and length of dykes.

The relations between the various eruptive rocks appear to be somewhat different from those supposed in previous reports. In the Sudbury sheet, it has been possible to separate and map out a series of greenstones and schists, which are the oldest eruptives met with. These are cut through and altered by what is commonly called the 'younger' granites and the breccia. formed by the invading granite; and the included greenstones cover considerable areas which are capable of being mapped. The younger granites themselves contain many fragments and even areas of these intruded greenstones. The norite, with which the nickel and copper-bearing sulphides are immediately associated is intrusive through and cooled against both the greenstone and breccia, and in many places a well-marked selvage or finer-grained portion of the norite is seen in the vicinity of the line of junction. The relation of the granite and the norite is, however, more complex, for although at one point the rock has cooled against the granite, as in the vicinity of No. 2 mine, Copper Cliff, at other places not far distant irregular tongues or apophyses of the granite apparently pierce the norite. It is probable therefore that their periods of intrusion were so closely synchronous that they overlapped in their period of crystallization, and that the later secretions from the granite magma forced or ate their way into the norite. Age relations of eruptive rocks.

The action to which the now famous nickel and copper ore bodies owe their present position and dimensions is much more complex than at first supposed, but the detailed examinations of many of the more important ore-bodies has served to emphasize very clearly some of the conditions attending and influencing their formation, and which were either minimized at first or overlooked altogether. These immense bodies, often of very pure sulphides, are no doubt, as generally supposed, genetically connected with the huge bathyliths of intrusive rocks with which they are always associated. It is also equally true that this sulphide material was introduced simultaneously and as integral portions of this same magma.* In obedience to Sorets' principle governing the crystallization of complex solutions, these sulphides are segregated together for the most part in the immediate neighbourhood of the cooling surface which may be granite, breccia, greenstone or the several clastic rocks already described. Such a hypothesis however is manifestly inadequate to explain the presence of the larger ore bodies at least, and a more intimate acquaintance and study of their occurrence shows rather clearly that solution and redeposition has played a very much more important part in their formation than has hitherto been supposed. There can be little doubt of the abundant presence of such Origin of nickel and copper sulphides.

* The Nickel and Copper Deposits of Sudbury District, Bull. Geol. Soc. of Am., 1890, pp. 135-3.

heated solutions, containing the various mineralizing agents, and they evidently began their work of dissolving out, transportation and redeposition, long before the magma had cooled, bearing their heavy burdens of sulphide material obtained from the magma to occupy the various cavities and fissures as fast as these were formed. It has long been remarked that everywhere in the vicinity of these ore-bodies, the inclosing rocks have undergone pronounced chemical and dynamical metamorphism. In many cases, all of the minerals are secondary and little or no trace has been left of the original structure. In addition, there is seldom lacking evidence of minor but appreciable and very frequent faulting and stretching, inducing the formation of the necessary spaces, while in many places there has been a replacement of considerable portions of the inclosing rocks by the sulphides. This extreme alteration of the wall rocks inclosing the ore bodies is the reason that the true nature and exact boundaries of the real parent plutonic remained so long unknown, so that the earlier petrographical descriptions referred to the rock as diorite, uralitic diorite, gabbro-diorite, diabase, uralitic-diabase and hornblende schists. The Baron Von Foullon and Prof. G. H. Williams were the first to call attention to the occurrence of the norite, but the true significance of their discovery was not appreciated until the appearance of Dr. T. L. Walker's 'Geological and Petrographical Studies of the Sudbury Nickel District' which must be regarded as marking a very decided advance in our knowledge concerning the true nature and relations of these deposts and their associated rocks.

Three main bands of norite.

There are three important bands of basic igneous rocks with which workable deposits of the various sulphides carrying nickel and copper occur. They may be distinct and separated, but genetically and mineralogically they are essentially identical. They likewise probably belong to the same geological period and are nearly, if not quite synchronous.

Northern band.

The most northerly of these bands starts from the old Ross mine (W. R. 5), near the line between lots 5 and 6, on the concession line between III. and IV. of the township of Foy, and extends in an east-south-east direction into the township of Bowell, where on lot 6, in Con. II. it branches. One band runs south-west into the townships of Lumsden and Morgan, where its limits have not been definitely ascertained. The other band runs on to the east, cutting across the township of Wissner and crosses the Vermilion river, immediately north of Bronson lake. Trending still more to the north, it connects with the large basic area to the west of Lake Wahnapitae. This mass extends for the most part in a southerly direction, and as far as at present ascertained, is lost in the extensive sand and gravel plains of the eastern part of Garson and the western of Falconbridge. It is thus

so far uncertain whether this mass is continuous with the southern band of similar rock which, running through the third concession of Garson, is likewise covered up by the heavy mantle of drift. In my opinion this belt of basic igneous material which runs through Garson, extends in unbroken continuity beneath the drift, reappearing at the surface in the 4th and 5th concessions of the township of Falconbridge. It would however be extremely difficult to fully corroborate this view, as in many places the covering of sand and gravel is over 100 feet in thickness. Distribution.

The second important band of basic igneous rocks, according to the present state of our knowledge, starts on lot 12 in Con. III of Trill, extends north and north-east through this township into Cascaden, and crossing under Windy lake, goes on uninterruptedly through the north-west corner of Dowling to lot 2 in the 4th concession of Levack. There is probably then a considerable break between this and the Ross mine on the northern nickel range, on the one hand, and the basic band which runs through part of Morgan, but both bands are almost identical in mineralogical composition and are certainly genetic equivalents. It is along the northern contact of this band and the granitite gneiss to the north that the well known Levack deposits are situated. Middle band on Windy lake eruptive.

The most important and famous band of norite, however, is the southern one, which starting in more or less small and isolated patches in the township of Drury, coalesces into one large band in the eastern part of this township. It then extends in a north-easterly direction as far as lot 3 in the 3rd concession of Garson, a distance of over thirty-two miles. The extremely basic portion would average nearly two miles in width throughout this length. The basic rocks extend over the greater part of the 3rd, 4th, 5th and 6th concessions of the township of Denison. About lot 2 it attains its maximum width of nearly four miles, but a short distance east is divided up into two belts by the intrusion of a mass of "augen" granitite-gneiss. The northern, which is the more important of these two belts, runs in a direction of N.N.E. through the north-eastern part of the township of Denison and the south-eastern corner of the township of Fairbank. Thence it extends across the Vermilion river, covering the northern part of the 6th concession of Graham, and portions of Cons. I, II and III, of the township of Creighton. From this place it runs across the central part of Snider, through the north-western corner of McKim, and the south-eastern part of Blezard, and with the exception of lots 1 and 2, extends with unbroken continuity across the third concession of Garson. Through Creighton and Graham this band is about two Southern band. Distribution and extent.

miles in width, while near the Blezard line it measures nearly one and a half miles across.

On lot 2, concession III of Snider, this norite sends an irregular tongue or dyke-like extension south-eastward and south, on which are situated the mines of the Canadian Copper Company at Copper Cliff. This band runs across the north-east end of Clara Belle lake. Crossing Lady Macdonald lake, it runs with practically unbroken continuity as far as No. 2 mine. The famous old Copper Cliff mine is a veritable chimney of ore, occurring in connection with an isolated stock of norite which comes in contact with felspathic quartzites and green schist. The openings in the vicinity of the Ontario Smelting Works belong to three separate masses of norite, which are surrounded by banded tuffs and quartzite. It is difficult to obtain hand specimens from the small area of norite in which the Evans mine is situated, sufficiently free from the sulphide material for purpose of examination.

The southern belt of basic igneous rocks runs across the Vermilion river, covering parts of concessions III, IV and V of Graham; thence on through Waters and Snider, it keeps to the south of the granite and north of a prominent ridge of quartzite, passing the Copper Cliff between mines No. 1 and 2. It is made up chiefly of diorite and amphibolite with possibly minor bodies of norite and a large amount of tufaceous material. Another large, though irregular body of altered norite, forms the rough country east of Sudbury and north of the Canadian Pacific Railway. It sends branches north-east across concession VI, Neelon, and south-west forms a series of hills to the north of Ramsay lake and Kelly lake.

Nickel mines.

The Little Stobie mine, Dominion, the Davis property, Kirkwood and Cryderman mines, are situated on the borders of the main belt of norite with green schist. The Stobie and Frood mines occur in conjunction with comparatively small stocks or areas of norite, which are separated from one another. The Elsie mine occurs at the junction between norite on the one hand and green schist tuffs and hornblende porphyrite on the other. The Murray mine occurs at the junction between granite and greenstone breccias and green schists on the one hand, and the main band of norite on the other; while the old Cameron mine, further to the north-east, is found at the junction between the granite and norite. The North Star and Creighton mines occur at the junction between the granite and norite.

International nickel.

Perhaps the most significant occurrence in regard to the progress of mining in the district, during the year, has been the formation of the

International Nickel Company, under the laws of the state of New Jersey. This company is really formed by a consolidation of the Canadian Copper Company and the Orford Copper Company. The interests of the Anglo-American Iron Company and the Vermilion Mining Company have also been acquired by the new corporation, as well as the properties of the Nickel Corporation and the Société Minière Calédonienne, in New Caledonia. During the past summer operations at Copper Cliff were carried on very slowly, but it is intended to resume work during the coming season on a much more extended scale than ever.

The Mond Nickel Company are actively engaged in the production of a high grade matte, which is shipped in barrels to the refinery at Clydacw, Wales. It is stated authoritatively that these works have a capacity of about 1,000 tons of refined nickel per annum. The Lake Superior Power Company have also been mining at Elsie, and smelting the ore at the Gertrude mine. But beyond some prospecting and examination of various locations, all of the other properties are idle. Mond Nickel Co.

STATISTICS OF NICKEL AND COPPER PRODUCTION IN ONTARIO. Statistics.

Year.	Ore Raised.	Ore Smelted.	Nickel Content.	Copper Content.
	* Tons.	Tons.	Tons.	Tons.
1890	130,278	59,329	....	....
1891	85,790	71,480	....	....
1892	72,349	61,924	2,082	1,936
1893	64,043	63,944	1,653	1,431
1894	112,037	87,916	2,570½	2,748
1895	75,439	86,546	2,315¾	2,365½
1896	109,097	73,505	1,948½	1,868
1897	93,155	96,094	1,999	2,750
1898	123,920	121,924	2,783¾	4,186¾
1899	203,118	171,230	2,872	2,834
1900	216,695	211,960	3,540	3,364
1901	326,945	270,380	4,441	4,197
1902	219,703	211,847	5,347	3,503

*2,000 pounds.

ARTESIAN BORINGS, SURFACE DEPOSITS AND ANCIENT BEACHES IN ONTARIO.

Dr. Robert Chalmers.

Work during winter of 1901-2.

The winter of 1901–2 was spent in the office, compiling the data collected in south-western Ontario during the previous summer, relating to petroleum, natural gas, salt wells and water supply, and in examining drillings, correlating logs of wells, etc. Information was furnished to drillers and others from time to time where work was going on. Proofs of my report on the surface geology of western New Brunswick were also revised and the report, with accompanying maps (No. 1 N.W. and No. 2 S.W.) was prepared for the Annual Report, vol. XII.

Character of surface deposits in Glengarry county, Ont.

Early in May, a few days were spent with Dr. R. W. Ells, of this Survey, in Glengarry county, Ontario, examining the surface deposits there. The general surface of the country forms a plain about 350 feet in height * with a slight descent towards the St. Lawrence river. Moraines or boulder-clay ridges occur in some places, which trend approximately north-east and south-west, and numerous boulders from the Archæan rocks are scattered about over the area. Terraces, or water-levelled plains, usually consisting of coarse materials, occur associated with the boulder-clay ridges in certain localities, and appear to have been formed of the materials derived from the latter by their denudation during the Pleistocene submergence. These beds, though resembling boulder-clay, are usually stratified, and moreover, they contain marine shells of the following species,—*Saxicava rugosa*, *Macoma Balthica*, *Mya arenario*, etc., which prove their marine origin.

Nature of the field operations of 1902.

On June 6, I began the regular work of the season, which was, for the most part, a continuation of that of 1901, embracing, besides the investigations respecting matters of economic importance, a detailed examination of the surface deposits. Some of the shore-lines of the ancient lakes were traced, wherever it was practicable to do so, and these are shown on the accompanying sketch-map. Though a large body of facts has been obtained, many of them new, full data from all parts of the interlake peninsula are not yet at hand, and further study of the region is necessary, especially in the north-western part, before a full and detailed report on it can be prepared.

---

*All the elevations in this report are referred to mean sea level, unless otherwise stated.

At Brockville a few days were spent endeavouring once more to ascertain the nature of the contact between the known marine Pleistocene beds and the clays and sands to the westward, which appear, so far as studied, to be of lacustrine origin. Gray and yellow sands holding shells of *Saxicava rugosa* and *Macoma Balthica* along with numerous calcareous concretions, were found on the banks of the St. Lawrence river half a mile above Brockville. Further west, near Lyn, gray, stratified clay was seen to underlie, and to be in contact with, these yellow beds. Similar deposits, occupying the same relative position, occur at the Grand Trunk railway bridge below Lyn. These two kinds of clay, the uppermost almost invariably containing concretions, were noted in a great number of places on the north side of Lake Ontario and Lake Erie.

PETROLEUM AND NATURAL GAS.

Considerable exploratory work in search of oil and gas has been carried on in the province of Ontario during 1902, and though most of it was unsuccessful, yet drillers and experts do not seem to have been discouraged. Oil and gas have been discovered in a few new localities, more particularly at Wheatley and in the townships of Romney and Raleigh, in the county of Kent. The first place where these were found was in the village of Wheatley, on the boundary line between Essex and Kent counties, at the depth of 1,110 feet. After the well was 'shot' a pressure of 440 pounds was reported. Gas from this well was piped into the dwellings, stores and factories in the village. Meantime, other wells were sunk in the vicinity and to the east, in Romney township, about two miles and a half from Wheatley, where the drill reached depths of 1,100 to 1,300 feet. Large areas of land were taken up there and north-eastward towards Charing Cross in the township of Raleigh and to Northwood in the township of Harwich on the supposition that an anticlinal axis extended in that direction. Two of the wells in Romney township were yielding some oil and gas at the time of my last visit in October and drilling operations were quite active. In November, oil was struck in Raleigh township near Charing Cross, about eight miles south of Chatham at a depth of 320 feet, or about 200 feet into the Corniferous limestone. Very exaggerated reports concerning this well were published, but from last accounts it was yieldsng oil with a pressure of about 140 pounds. The sinking of other wells was at once undertaken in the vicinity in concessions 12, 13 and 14 township of Raleigh, to depths ranging from 320 to 370 feet. Four of these are reported to be giving oil in greater or less quantities, but whether they are of permanent value or not remains to be seen. At

Explorations for oil and gas.

Wheatley.

Raleigh.

Northwood. Northwood, seven miles east of Chatham, near the Grand Trunk railway, oil has also been discovered, but in what quantities I have not ascertained. If an anticlinal axis extends from Wheatley to Northwood and Bothwell as maintained by some of the oil operators, its length must be about fifty miles in a north-east and south-west direction and the probabilities are in favour of profitable wells being found at some points along its course. The oil is, however, met with at two different horizons. At Bothwell, Northwood and Raleigh it occurs in the Corniferous limestone at depths between 300 and 400 feet, while at Romney and Wheatley it is found 1,100 to 1,300 feet deep in a hard vesicular limestone similar to that in which gas occurs in Essex county.

Collingwood. In regard to natural gas, it may be added that there has been a renewal of explorations at Collingwood, and the Trenton rocks there are now yielding it in limited quantities, sufficient, however, to heat and light some of the dwellings and drive the machinery in a few industrial establishments. The gas is found at depths varying from 100 to 300 feet, and at two or three horizons in each well, the surface deposits being from 30 to 40 feet thick. The first gas occurs at about a depth of 135 to 170 feet, or 100 to 149 feet in the rock, while the deepest gas rock is, as previously stated, at 300 feet or more below the surface. In Mr. Wm. Carmichael's well on Campbell street, in the town of Collingwood, the following beds were passed through:—(1.) Clay, 25 feet, hardpan, 8 feet; total for surface deposits, 33 feet. (2.) Trenton limestone, first gas at 135 feet; second at 165 feet; third gas at 237 feet, and the fourth and deepest at 288 feet; total depth of this well, 301 ft. 2 in. This may be taken as a typical example, showing the depth of the gas strata in all the wells sunk at Collingwood. The pressure in these wells is only from 20 to 30 pounds. A well was recently put down at the base of the Niagara escarpment, near Kirkville, passing through the Utica shales before reaching the Trenton, the latter being penetrated to a depth of 200 feet. A pocket of gas was encountered at this depth, and the pressure was so great as to throw out the water which was in the well and stop work; but it soon fell back to what it is in the wells in Collingwood. The greatest number of wells producing gas are found along a north-east and south-west belt, which passes through the town, though a few sunk to the south of this line have yielded gas.

Niagara escarpment near Collingwood. Three wells were put down on the high grounds west of the Niagara or Blue Mountain escarpment in 1901 to test the Trenton and other rocks there for gas, the heavy capping leading the drillers to suppose that the conditions were more favourable for an increased flow than in the valley to the north. One of these wells yielded a trace of gas, but the two others gave neither gas nor oil.

In the older and larger gas fields, exploratory work and drilling have been continued in some localities, more especially in Essex county, but, so far as I could learn, without much success. The export of gas from the last-mentioned field to Detroit, U.S., was stopped in the autumn of 1901, but although the wells have been thus relieved, a steady though slow diminution in the flow of gas from the whole territory is apparent. In the Welland field a lessening of the flow is not so evident; nevertheless it is well known that the pressure there is also slowly diminishing.

Gas production in Essex and Welland field.

SALT.

The salt industry is still in a backward condition, though a new salt block has been erected at Sandwich, Essex county, and two new wells sunk near Sarnia, reaching a depth of 1,680 feet, and penetrating thick seams of rock salt. The works of the Windsor Salt Company have also been enlarged.

The salt industry.

The great extent and thickness of the salt beds of Ontario were referred to in the last Summary Report. During the past summer inquiries were made regarding the limits of the area occupied by them, and it was found that the opinion which prevails among the best informed of those engaged in the manufacture of salt is that the beds occupy a single basin and are practically continuous throughout. There are probably local areas in it without salt beds, these having formed islands in the sea or lake of the Onondaga period upon which salt was not deposited. The salt basin extends from a point a few miles north of Kincardine, Bruce county, to Windsor or Sandwich, Essex county, a distance of about 170 miles, and its greatest width across the central part of Lambton county is about 40 miles. Whether it reaches the Lake Erie basin is doubtful, the wells drilled for gas near the lake not indicating salt. Neither is the western border known, but the salt basin probably extends below the waters of the southern part of Lake Huron and below St. Clair lake and St. Clair and Detroit rivers. The eastern and southern limits are irregular, but have been traced with some approach to accuracy from its presence or absence in the wells sunk in this part of Ontario. Six beds of rock salt, one above another, have been passed through by the drill in Bruce county, and also in the deep well at Petrolia, but it is from the upper seams only that the brines used in the manufacture of salt are taken. The depth of the rock-salt is somewhat variable in different parts of the field, and the beds have evidently the same dip as the inclosing strata. At Kincardine near the northern margin the uppermost salt seam is a little more than 300 feet below mean sea level; at Petrolia it is 615

Extent and thickness of the salt deposits of Ontario.

Six seams of salt.

Depth of salt beds.

feet below the same datum; at Courtright 1,020 feet, and at Windsor 985 feet. From these figures it would appear that the deepest part of the salt basin is in the western part of the area. At Courtright, however, only one seam, 22 feet thick, was struck, and it is possible the uppermost salt seams are absent there.

PLEISTOCENE GEOLOGY, ANCIENT SHORE LINES, ETC.

Reference to classification of surface deposits.

A general classification of the surface deposits of the interlake peninsula of Ontario was given in the Summary Report for 1901, and two boulder-clays, separated by thick interglacial beds, were briefly described. The work of the past season has shown this classification to be substantially correct, and though in minor details the sections of the deposits may, in some localities, be slightly different in their constituent parts, it is now evident that there were, at least, two glacial periods in this region with an interglacial interval of considerable length between them. Evidences of these were noted as far east as Kingston, also at Trenton, Oshawa and along the Belleville and Midland railway. Further west the two boulder-clays were seen at Toronto, Woodstock and other places too numerous to mention. The stratified clays and sands associated with the boulder-clay deposits can only be very briefly referred to in this report.

Two boulder-clays.

Ancient Shore lines of the Great Lakes.

Ancient shore lines of the great lakes.

In south-western Ontario the evidences of ancient water-levels above the shores of the present lakes are shown in a number of places by shore lines cut into the clays, sands or gravels along sloping surfaces, and also by terraces formed of stratified deposits, and in some instances by beaches which have been thrown up by the waves. The strongest example of an ancient, abandoned water-level is probably the terrace abutting against a slope, but all three forms can be seen in numerous places in this region. In regard to the shore lines which were observed, I shall take the highest first, and the others in descending order. The elevations are all referred to mean sea level. Dr. J. W. Spencer speaks of shore lines or terraces 'up to altitudes of 1,700 feet,'* but the highest of those observed by the writer did not reach that elevation. A terrace or bench extends for miles along the Niagara escarpment in Simcoe county at a height of about 1,400 feet (bar). In the central part of the peninsula, along the Owen Sound branch of the Canadian Pacific Railway, a number of local shore lines

Highest shore lines observed.

* A review of the history of the Great Lakes, American Geologist, vol. XIV, No. 5, p. 296.

and terraces were observed,—one at Caledon station and Millville Junction, 1,356 feet in altitude extending westward some distance. Another lower terrace runs nearly parallel to the latter at a height of 1,260 feet. But the most extensive of these high-level terraces—one which may really be called a plateau, is upon the northern watershed of Lakes Ontario and Erie, extending from Durham county westward to Perth county. In Durham, Ontario and York counties it is comparatively narrow and the general direction is approximately east and west the average elevation being about 1,100 feet. A wide depression crosses it east of the Credit river.

West of this the plateau expands into a broad, roughly triangular area with the town of Stratford at about the centre, and is limited to the north-east by the higher grounds of Wellington and Grey counties. Upon its surface low hills and ridges rise above the general level, but for the most part it is flat and even and occupied by gravels, sands, silts and clay in a stratified condition, though boulder-clay is often seen levelled off at the same plane as the stratified beds. This plain increases in height from east to west, at Pontypool, in Durham county, the elevation being 1,100 feet, while at Stratford, about 140 miles to the west, it is 1,200 feet.

Shore lines, how far traced.

Descending from this high-level terrace, we reach a shore line which, excepting the Iroquois beach, is the best defined of those met with on the north side of the lower Great Lakes. Its average elevation above mean sea-level is 890-892 feet, according to the railway levels, on which all the measurements were based, and it seems to be practically horizontal throughout. This shore line was traced from Trent river, in Northumberland county westward to Hyde Park in Middlesex county, a distance of fully 200 miles. From Hyde Park it trends northward, and was followed to Clinton, though not as closely as in its east-and-west extension. East of the Trent river, or rather east of the Belleville and Midland railway, (Grand Trunk,) it could not be definitely traced. In its general features it exhibits cut terraces, wide, water-levelled plains, and in some instances, wave-built beaches. It is intersected by a transverse valley in its eastern prolongation through which the Port Hope and Peterborough railway runs, but west of that it is continuous throughout, except where the Thames river crosses it. It was not traced farther north than Clinton or Holmesville, Huron county.

Gradients of the shore lines.

Below this there are traces of another shore-line higher than the Iroquois. Its elevation was measured at several points, for example, at Myrtle station, Grand Trunk railway, where it is about 775 feet; at a point south of Richmond Hill, York county; south of Harrisburg

Junction, Grand Trunk railway; north of Brantford, and at Kingscourt Junction, Komoka and Sarnia branch, G. T. R. The elevations vary from 775 feet, at Myrtle, as stated, to 705 feet in its westward extension; but this shore line has not been traced in sufficient detail yet to enable me to generalize in regard to it. The gradient seems, however, to be greater in the eastern than in the flat country in the western part of the peninsula. The Iroquois beach below this has a still greater slope westward, that is, between the Trent river and Dundas, according to Spencer and Collman.

Differential movements of the land indicated.

The highest of the water-planes and shore lines referred to are, no doubt, the oldest, but even these must have been produced since the last glacial period, as they bear no traces of ice-action. When the 775-705 feet shore line was being formed, and still later, the Iroquois, the 892 feet one, as well as the 1,100-1,200 feet plateau, must have had an eastward or north-eastward slope. The 892 feet shore line however, strange as it may seem, has just about returned to its original horizontal position. The changes of level indicated by the several altitudes and gradients of all these shore lines, viewed in relation to each other, point to differential or east-and-west see-saw movements, which were much more complex than hitherto supposed. Further study of the phenomena is very desirable.

Clays, Sands, Gravels, etc.

Stratified deposits, clay, sand, etc.

Considerable information has been collected relating to the character and distribution of the clays, sands, silts, marls, etc. Besides the boulder-clays referred to on a previous page, the stratified clays and sands form the largest part of the surface deposits, occurring everywhere throughout the province, and the industries depending upon these materials are rapidly increasing in value and importance. The manufacture of bricks and tiles is now carried on near most of the cities and towns, and no difficulty seems to be experienced in getting clay and sand suitable for this purpose. At most of the brickyards the surface clay and sand only are used, which burn into red bricks. But in the south-western part of the province large quantities of white or cream-coloured bricks are made from the Erie clay, which underlies the clay above mentioned. The localities where the different kinds of clays and sands occur are so numerous that it is impossible to mention them in this report. But they have been described in considerable detail by Dr. Robert Bell in the Geology of Canada, 1863, pp. 896-915. Sands and silts often form ridges and mounds upon the higher terraces between Manvers and Whitechurch townships. The detailed information collected during the past two seasons concerning the surface deposits

Uses to which they are now being put.

Bricks and tiles.

Description by Dr. Bell in Geology of Canada, 1863.

must be passed over in this summary, and await a more detailed report.

PEAT.

A good deal of interest is taken at the present time in the manufacture of fuel from the peat bogs of Ontario. Experiments in drying and pressing the crude moss have been going on for a number of years and attempts made to produce a marketable article of fuel which would be cheap, of small bulk, and easily handled. Recently it appears that at three or four of the peat bogs at least, the efforts of those interested have been successful, while at others the methods devised are being tested and will probably be adopted. Briefly described, these methods are:—First, the draining of the bog; then air and sun-drying the crude moss in the field until the quantity of moisture in it is reduced to 50 or 60 per cent or less; afterwards collecting and bringing it in to the peat works. These operations constitute what is called 'harvesting' the peat moss. When brought to the works it is either piled in heaps or stacks, or delivered into a machine called a 'breaker,' which breaks or cuts it into small particles to facilitate drying, after which it is carried to the drier by an endless belt and buckets. Several driers have been invented and tested, but the one known as Dobson's seems, so far, to have proved most serviceable in the drier peat mosses of Ontario. It is a hollow steel cylinder, 30 feet long and 3 feet in diameter, which is placed inside a brick furnace and mounted on an axle at a slight inclination from a horizontal position. Heat is applied under the higher end, the peat from the breaker being delivered into this end automatically from above. The drier is made to revolve slowly, and 'angle irons' inside, arranged at proper distances apart, lift and break up the peat still more as it is moved about inside the drier, until, by gravitation, it reaches the lower end of the cylinder. From the drier it passes, as a fine dust, into receptacles which convey it to the press. It is then dropped into the dies, of which there are eight on a revolviug block, and is there subjected to a pressure in each of not less than 50 tons weight. By another movement of the press the block of pressed peat, or briquette, is forced out below and caught up by the buckets of an endless belt and carried to a storehouse or bin. At the Beaverton works, where operations seem to be well systematized, the whole series of processes, from the cutting of the peat in the field to its storage in the bin, costs only about 90 cents a ton. From twelve to fifteen tons of pressed peat are produced daily with only one drier. These works have been in operation for two years, and the peat briquettes find a ready sale at Beaverton and the nearest towns.

Peat.

Methods of converting it into fuel, or briquettes.

Description of drying process.

Presses.

Beaverton peat works.

A peat bog situated about eight miles north of Stratford, contains 1,200 or 1,300 acres, and is known as the Stratford bog, or Huckleberry marsh. Here the manufacture of peat fuel has also been undertaken. The whole process of harvesting, drying and pressing the peat moss into briquettes is precisely similar to that of the Beaverton works, and so far as I could learn, is also proving a success. The plant is the same as that of the Beaverton Peat Fuel Company, and indeed, has been constructed from Mr. Alex. Dobson's patent.

Stratford bog.

The Welland peat bog is situated in Welland county, and contains 4,000 acres or more. It is now six or seven years since the company operating here (The Welland Peat Company) began the exploitation of this bog, and experiments in drying and pressing the moss, have meantime, passed through a number of stages. The preparation of moss litter was first tried, but eventually, this gave way to the manufacture of peat fuel. The experimental stage, seems now, however, to have been passed, and plant adapted to the special requirements of the peat moss has lately been installed. The character and condition of the peat are somewhat different from those of the Beaverton and Stratford bogs. The Welland moss is wetter and different methods have had to be employed in harvesting and depriving it of the moisture it contains. It has been shown by experiments made at other peat works, that the maximum amount of moisture left in peat after passing through the press, must not be more than 10 to 12 per cent, in order that the briquettes may not be brittle or break up readily. But it was found that passing the peat of the Welland bog through a 30-foot drier, once, did not reduce the quantity of moisture to this point. Hence, the company had to get a double or triple drying-cylinder, equal to about 90 feet of a straight drier, to effect that end. The difficulties encountered in the drying process having thus been overcome, three new driers were about being put in at the time of my visit, making four in all, with a capacity for producing 100 tons of pressed peat a day.

Welland bog.

Drying and compressing plant at Welland.

The peat of this bog has to be screened before it is put into the breaker as it contains roots of trees and shrubs. These roots are, however, used for fuel under the driers, instead of crude air-dried peat, as at Beaverton and Stratford.

Victoria Road peat work.

At Victoria Road, on the Trent Valley canal, about two miles north of Kirkfield, there is a peat bog of 110 acres, and here an attempt was made by the Trent Valley Peat Fuel Company to manufacture fuel on a large scale. Very extensive works were erected and operations carried on for two years or more, but owing to the difficulties met with in the drying process also, they were closed in 1902. The peat moss

is under water, and had, therefore, to be dredged, and the efforts which were made to remove a portion of the water it contained by pressure before conveying it to the driers, were not successful, and besides, were, I was informed, too expensive.

Another peat bog to the north of this, on higher ground, is much better situated as regards drainage and facilities for drying by the air or sun, and it is reported that the company above mentioned may commence operations there.

Rondeau bog.

The Rondeau peat bog is on the west side of Rondeau Harbour, Kent county. The surface of the moss is nearly on a level with that of Lake Erie, and at the time of my visit the pit from which the peat was being taken was flooded and operations had temporarily ceased.

Brockville peat.

A large peat bog lies three miles north of Brockville. Here the manufacture of peat fuel was undertaken, but the company was met by the usual difficulties in the drying and compressing processes, and had to close operations.. The property, I am informed, has since been acquired by the Peat Industries, Limited, of Brantford, and their improved plant was to be installed at an early date and operations resumed. The bog is rather a wet one, the artificial channel which drains it apparently not having been cut deep enough.

Newington peat works.

Preparations for manufacturing peat fuel have also been commenced at Perth, Picton, Galt and other places, and the Dominion Peat Company of Brantford is about to begin the manufacture of fuel and coke from the moss of a large bog at Newington, Stormont county.

Bogs not yet utilized.

Other peat bogs were noted in different parts of Ontario, for example at Redmonds Pond, west of London, at Jacks lake, south of the mouth of Nottawasaga river, also in the basin of Balsam lake, and at the Mer Bleue, east of Ottawa. No attempts have yet been made to work these for fuel or moss litter.

Present methods of drying and pressing peat not capable of producing fuel in large quantities.

The question is often asked, can peat fuel be prepared by the present methods of drying and pressing it in sufficient quantities to enable the manufacturers to place it in the fuel markets of the country for general sale along with coal and wood. Hitherto this has not been done, and the limit of production seems to be reached when the nearest towns and villages are supplied. The great difficulties in regard to preparing it in large quantities lie in the preliminary air-drying or so-called 'harvesting' processes. In winter, as is well known, the bogs are frozen solid, so that it is impossible to obtain the crude peat then to carry on operations. Under these conditions, how can a

manufacturer get a supply sufficient to keep the driers and press running all the year round? The present method is to store up as much of the air—and sun-dried peat in the summer months as possible. But in wet summers this quantity must be limited, indeed, the managers of peat works inform me that, as a rule, they can only get about 100 days in the year to dry the crude peat in the field. It is evident therefore, that if, on account of a wet summer, or other causes a sufficient quantity of the raw material is not collected, the industry will be seriously hampered. However, matters are not so bad as may seem at first glance. Considerable quantities of the raw peat are usually stored. Moreover, it has been proved by experiment that it is not necessary to store air-dried peat under cover for winter use, if the moisture in it is reduced to 50 per cent or less. Stacking or piling it up in the open air is just as effective in keeping it dry, that is to say, it will remain in the same condition in regard to the contained moisture as when collected. Peat well dried by the air and sun does not usually contain more than from 20 to 40 per cent of moisture. Large heaps of air-dried peat were shown me at some of the bogs which had been exposed to the weather for a year or more. Openings made in these showed this peat to be as dry as when collected except 12 to 15 inches on the outside, which was the depth to which the rain had penetrated. From these facts it would seem that in order to have a sufficient supply of crude moss on hand to keep the driers and stamps of any of the peat works in operation the whole year round, it is necessary, first, to have a large drying area, and second, to employ a considerable number of men during the dry weather of summer for the outdoor operations. The air-drying process is the cheapest, and probably the most expeditious in the preliminary stage. At the Beaverton works the total cost up to the delivery of the raw peat at the breaker is reported to be only about 40 cents to the ton of pressed peat.

Only about 100 days in the year in which peat can be sun-dried.

Large drying areas necessary.

Cost of air drying process.

Peat briquettes.

Peat briquettes are impervious to the moisture of the atmosphere, if kept under cover, but if exposed to rain or snow they absorb water and swell up and burst. They have a calorific power of about three-fourths that of ordinary coal, while that of crude peat is about half that of coal, the accurate proportion being as 1 to 1·8.

Dead bogs.

The peat bogs or moors of Ontario consist, to a large extent, of dead peat, those parts which contain the living moss being limited and scattered. The growth and accumulation of peat here has, therefore, practically ended. The dead condition of these turbaries is due to several causes, some of which are not easy to explain, but the principal causes seem to be (1) the clearing away of the forests and the partial

dessication of the country surrounding the bogs; (2) artificial draining and attempts at cultivation; (3) fires overrunning them in dry seasons, &c. In consequence of these changes the quality of peat is more or less impaired. Dust and other mineral matters are more likely to get into it, especially near the border, when the peat is dead. Moreover, the lower part of the bog is then more liable to decompose, the fibre of the peat to become destroyed and pass into humus. Peat fuel manufactured from material of this kind, therefore, is not likely to be as clean and free from mineral matter as that obtained from green living bogs. Ordinary clean peat should not contain more than about five per cent of ash. The upper part of the Ontario bogs, that is the part from two to four or five feet below the surface, probably contains the best peat for fuel, and the centre of the bog will have cleaner moss than that at or near the margin.

In closing I desire to thank Mr. Horace P. Chamberlain, general manager of the Imperial Oil Company, Sarnia, for a number of logs of wells sunk in Ontario, and Mr. Charles O. Stillman, general superintendent of the Sarnia Oil Refinery, for information courteously given. To Messrs. James Kerr, Petrolia, A. F. Hunter, M.A., Barrie, Wilson Irwin, Toronto, Alex. Dobson, Beaverton and William Carmichael, Collingwood, I am indebted for assistance and various acts of kindness. Acknowledgements.

THE ALGONQUIN SHORE-LINE IN SIMCOE COUNTY, ONTARIO.

Mr. A. F. Hunter.

Simcoe county covers 1,627 square miles, has a maximum length of 58 miles, and a greatest breadth of 52 miles. In this limited area, the ancient Algonquin shoreline has a lineal extent of some 450 miles. This great length is owing to its numerous windings around peninsulas, bays, islands and every other form of shoreline. Area of Simcoe county.

It follows from this circumstance that more than half of the surface deposits of the county are the direct products of the Algonquin water, notwithstanding the fact that many other shore-lines are found here. No other physical agent was so potent in producing the present economic conditions of the county. For, in addition to the phenomena connected with existing parts of the ancient beach, there are very many wide tracts of boulders lying far out from the shore-line which were shoals during the existence of the Algonquin lake or sea, and they owe their denudation to this great water-body. Hence the Algonquin lake or sea has been the dominant factor in making the county's soils and deter- Origin of surface deposits.

mining its watercourses, and even in modifying the distribution of its flora and fauna.

Area of former land.

The contracted area of the dry land in what is now the county of Simcoe in Algonquin times was about 680 square miles, consisting chiefly of islands and crab-like peninsular forms. The remaining 947 square miles lay under water with the meandering shore-line of 450 miles. It is a singular fact that the 680 square miles thus unaffected is nearly all good soil, while the 947 square miles consist largely of sands and gravels, deposited on the bed of the lake. In most places the Algonquin deposits completely obliterate any glacial characteristics that might once have existed, but above the shore-line there are a few features that may be attributed by some geologists to glacial agency.

Former islands.

In the southern and western parts of the county, the Algonquin sea lay against the mainland. A group of large islands extended nearly from Lake Simcoe north-westward to Georgian bay. The largest island, which covered about 120 square miles, and included the chief part of the township of Oro, lay nearest Lake Simcoe; and in a general way the others diminished in size toward Georgian bay. The longer axis of this island group seems to follow an old escarpment which was closely parallel with that of the Blue mountains at the west side of the county, the islands being the portions which have escaped denudation. Some exposures of rocks occur along the Blue mountain escarpment, but none in the row of islands, the latter being heavily covered with drift. The general direction of the broken face of the old escarpment, which I shall call the north-easterly escarpment, as shown by the Algonquin shore-line along the islands, is north-west by west. That of the shore-line along the Blue mountain escarpment is north-west by north. Thus they are closely parallel with each other, but not exactly so.

The Algonquin lies about midway in elevation in a series of shore-lines, all of which are more or less definitely marked in this county. First, I will pass upward from this shore-line, taking it as the datum in my descriptions.

Other old beaches.

One of the most prominent features of the Algonquin beach is an upper strand, about 40 feet above the main cutting. This is observable for the most part where the land slopes very gradually; at places where the slope of the surface is steep near the shore line, its faint traces have been entirely obliterated by the strong action of the waters during the subsidence which followed. This appears to have been the starting level of the true Algonquin shore-line. Wherever the name Algonquin is used in this report, it refers to the Lower Algonquin beach, which is, in every respect, the more important.

Besides the markings at 40 feet above, there are others at 70 feet and again at 110 feet also above the principal shore line. All three become well marked shore-lines along the north-easterly (broken) escarpment, but along the face of the Blue mountain, I am unable to recall any but the markings at 40 feet, which I regard as a part of the Algonquin itself, or the earliest stage of it. The other two are probably somewhat local, appearing as they do along the more exposed places. All three are connected with phenomena due to the action of shore ice.

The next prominent shore-line above the Algonquin occurs at about 160 feet. Where it is well preserved it appears double, the two strands being separated by a space of about 15 feet. Its double character suggests possible tidal action. This 160 feet shore line has an oceanic aspect. It is not always distinctly defined, but is accompanied by evidence of much laving, and a broad, though sometimes eroded plain beneath it. Being much older than the Algonquin beach, it is not nearly so well preserved. One finds the Algonquin marked in ten places for one in which he finds the 160 feet shore line, but this difference may not be entirely due to the difference in age. The latter is easily traceable, however, by its broad water-levelled plain. Shore line at 160 feet.

There is abundant evidence in the zone between the Algonquin and the 160 feet shore-line of a period of thick shore ice, such as might be produced by a sub-arctic climate like that of the present Great Bear lake, but there is no evidence within my range of observations of any land ice or other glacial features. The evidence of shore ice is furnished by the multitudes of ice-formed reefs to be seen in sheltered bays within the zone. The uppermost layer in those cliff exposures is usually a mixture of gravel, clay and pebbles, having a cemented character in most places. My observations led me to regard this mixture as debris from the deposits of shores immediately above the Algonquin, and I further consider the thick deposits of sand always underlying this material as the products of the strong shore-line at 160 feet. In one instance, viz., on the north half of lot 16, concession XII., Innisfil, I observed this thin cemented covering of boulder clay to dip with the slope of the hill in the side of which the exposure occurs.

The next shore-line is one about 230 feet above the Algonquin. This has a terrace even broader than that of the 160 feet shore-line, but its actual water-line is more indistinct. Indeed, the shore-lines become more extended and with a more oceanic aspect as one ascends the series. There are shore-lines at about 310 and about 410 feet above the Algonquin, in addition to those above referred to. The Higher terraces.

altitudes of these are deduced from my observations on the 'Insular Tract' in North Simcoe. Similar high shore-lines occur up the sides of the Blue Mountain escarpment in the western part of the county, and they are probably at corresponding altitudes, but I have not attempted to correlate the two series, or rather the two parts of the same series, higher than the 160 feet shore-line, which is a conspicuous feature along both escarpments of the county.

Shore-lines below the Algonquin.

Returning to the Algonquin and passing downward from it, the first shore-line is found at about 60 feet below. The best markings of this shore are found along the north-easterly escarpment, but are occasionally met with in other parts of the county, though, as a rule, only faintly. This shore-line, or a counterpart of it within an inner basin, occurs a short distance south and west of Angus. The entire valley of the Nottawasaga river above this is devoid of shore-lines until the Algonquin is reached, and between the two there is a continuous plain. In connection with this shore-line, which I shall designate by the letter A for the sake of brevity, some beds resembling boulder-clay occur in protected places. Instances of these will be found mentioned in subsequent parts of this report.

The next shore-line beneath A is some 50 feet lower than the last mentioned, and is considerably stronger than A. I will designate it as B. The succeeding ones, C and D, are also strong. In fact, it might almost be said that this infra-Algonquin series, which has been called the Great Nipissing series by F. B. Taylor, increases in strength as we go downward from the Algonquin. The later members of the series are marked only against the north-easterly escarpment. Westward, near Collingwood, none but the first three are to be seen, the later ones having coalesced with the existing shore of Georgian bay.

I cannot assert positively how many shore-lines may exist in this infra-Algonquin series. There are at least five, and as you travel north-eastward, where the uplift raises the whole series higher above the present level of Georgian bay, new ones seem to make their appearance. The series ends in uncertainty.

Fresh-water shells.

Fresh-water shells begin to make their appearance with the shore-line B. They increase in abundance until we reach shore-line D, in connection with which great deposits of shell-marl occur in the flats of the Nottawasaga river toward its mouth. The great abundance of fresh-water shells at this stage of the subsidence suggests a much warmer climate than even our present meteorological conditions. Dr. Robert Bell has found similar evidence of a milder interval than the

present day in deposits on the north side of Lake Superior. (The Geological History of Lake Superior, Trans. Can. Inst., vol. VI., p. 54).

Ancient bays.

Along the Blue mountain escarpment, especially toward the head of the Georgian bay of Algonquin times, the shore-line has many bays and deep indentations; but along the north-easterly escarpment, especially at the northernmost islands, the outlines have a smooth rounded character which is quite noticeable when the contour of the shore-line is seen on a map. This difference, which is accompanied by a corresponding increase in the strength of the cuttings at the outermost places, seems to be entirely due to the greater exposure at the north to a more active sea. The difference is not traceable to uplift or deformation of the shore-line while the water body was cutting it, but almost, if not quite all, to the uplift in subsequent times. The markings at 40 feet above the Algonquin and the higher members of the infra-Algonquin series are quite parallel with the Algonquin itself, and show practically the same degree of uplift. They also show greater intensity along the north-easterly escarpment, and hence the whole phenomenon may be regarded as due to greater exposure to the wave action. I have identified the Algonquin, east of Lake Simcoe, at Bolsover and other places in that neighbourhood, and it has an appearance resembling that which it possesses in the more central parts of South Simcoe; hence I infer that the portions of it seen by me in Victoria county were amongst islands, where the action of the waves was more subdued.

Five periods.

In well developed examples of the Algonquin in Simcoe county, the main cutting is seen to be the result of the concentrated efforts of some five periods of intensity. In other words, the wave action was intermittent, as shown by the wave-built reefs of water-worn materials. Two such examples were noted in our survey of the shore-line in the township of Oro.

Uplift to the north-east.

The uplift or deformation of the Algonquin toward the north-east is quite considerable in this region. At Barrie the beach is 780 feet above the sea; at Silver creek, due north of Orillia town, distant 24 miles from Barrie in a straight line it is 875 feet. Along this line, therefore, the uplift attains 4 feet in a mile. Silver Creek is on the edge of the north-easterly escarpment. At Lisle, on the edge of the Blue mountain escarpment, its altitude is 750 feet. Lisle is distant from Barrie, 15 miles in a straight westerly course. Hence, along this line, which crosses the valley of the Nottawasaga river, the uplift is 2 feet to the mile.

Springs.

The old water-line of the Algonquin has a larger number of springs issuing along it than any other shore-line above or below it. This

feature led to the selection of the Algonquin cliff tops for the sites of many Huron Indian villages in the earlier days. Elsewhere I have dwelt more at length upon this circumstance, and upon the use of the ridges (morainic and other kinds) by the Indians for their forest trails.

Shell-marl.

Shell-marl deposits are conspicuously absent from the list of materials in the beds below the Algonquin shore-line. But, as above mentioned, thick deposits of this material occur in the deposits of some later shore-lines in this county. The action of a beach in making a deposit of shell-marl is to be seen on the present shore of Nottawasaga bay. The waves break up the shells into small fragments, but some escape whole and are thus found in the marl afterward.

Fossils.

Fossil fishes occur in Algonquin clays in the townships of Tay and Essa, and these cases will be found mentioned more particularly a few pages further on. They, however, did not come directly under my own observation, but I believe these instances constitute evidence that the Algonquin clay-beds are fossil-bearing. The sand deposits formed in shallower water than the clay can hardly be expected to retain any traces of fossils. Along the shore-line itself the intensity of the water action would be so great as to destroy shells and other dead organisms, if there had been any, and the coarse materials would not preserve them even if they had escaped destruction.

In artesian wells in this county, water does not rise above the Algonquin level; and there are no wells of this kind above the shore-line, so far as my experience goes. The case is different in other counties where wider bodies of the land of Algonquin times are to be found; but the land tracts of Simcoe county were too small to give any great force of water above this line.

NOTEWORTHY FEATURES ALONG THE ALGONQUIN SHORE-LINE.

Noteworthy features.

The Algonquin shore-line enters Simcoe county on lot 42, concession XII., Nottawasaga township and crosses the adjoining lots northward. Extensive boulder pavements are to be seen here, the finer materials from which the boulders have been separated and left, being found a few miles to the south-east. In general, the foot of the Blue Mountain escarpment corresponds with the Algonquin shore-line, more or less closely, and in some respects it is more conspicuous than any of the other shore-lines, above or below it.

Where it crosses Hurontario street or the eighth line of Nottawasaga, there are to be seen several ridges on lots 32 and 31. The shore-line

itself occurs southward in lot 31 near lot 30 on this line. At the crossing of the sixth line east, ridges and tracts of gravel are quite extensive, and the Batteau creek is very pebbly on lot 30 and for some distance above and below. The gravel has evidently been carried from the boulder tracts, six or seven miles to the north-west, as mentioned above. On this same (sixth) line southward from the crossing, for about two miles, including lot 27 and others south of it, the soil presents a much washed and flooded appearance, although there is good loamy farming land everywhere above an elevation of about 40 feet over the shore-line itself. The evidence furnished by this instructive place (on the 6th) is that the Algonquin lake or sea began its work about 40 feet above the main or final shore-line, and kept gradually settling down, leaving a zone of land for 40 feet above with a washed appearance. This feature is also seen at many other places, including an example on the ninth line of Vespra, but in the latter instance, there may have been some tumbling down of the final cutting, the 40 feet marking having been eroded away. Washed soils.

On the No. 24 side-road in concession IV., the shore-line is represented by a high gravel ridge, which is traversed by a stream. That part of the ridge lying north of the stream is boldly prominent and resembles a ridge of apparently similar formation in lot 9, concession XI., township of Tiny. Further lakeward than the gravel, viz., around the town of Stayner, there are thick deposits of sand whose origin has obviously been in the Algonquin water.

Passing now into Sunnidale, a prominent projection known locally as 'Cornhill,' protrudes fully two miles into the Algonquin lake-bed and far beyond the general line of the Blue Mountain escarpment. The land upon Cornhill is good, hence its name; but that on the flat ground around it is poor, having been washed by the ancient lake. The lake at the Algonquin level came very nearly making an island of Cornhill; a shore-line 70 feet above it did so. A strong and well preserved cutting of the Algonquin occurs along the outer or lakeward edge of Cornhill; this cutting having for its most easterly reach the boundary between lots 4 and 5, concession V. Up to this point in our itinerary, this is the best developed cutting we have encountered, and it is the strongest example I have observed anywhere from the place of beginning, although it cannot be compared for strength with some cuttings along the insular 'escarpment' in the north-easterly part of the county, made by the Algonquin waters. Cornhill,

The crests or ridges on Cornhill and in its immediate neighbourhood at this part of the escarpment, whether they are the results of glacial

phenomena or not, have a north-west and south-east direction, and in this respect they are exceptional, or differ from other ridges almost everywhere throughout the county. As they now appear on Cornhill their course suggests that they have been cut away to this shape. Through Nottawasaga, township up to this point the ridges have usually a north-east direction, so far as any order can be made out; and four miles south of Cornhill, at Banda, they again run north-east.

The cutting at the apex of Cornhill is the starting point of the extensive Pine plains, which will be referred to further on. On the cross road between lots 6 and 7, concession IV., Sunnidale, a little way north of the road to New Lowell, there are surface deposits of the highly coloured red sand with continuous deposits of whitish marl or other chalky substance in a powdered condition. This is a short half mile from the cutting and about 60 feet below the shore-line, the usual depth at which such deposits are found.

Along the south side of the Cornhill projection, a deep recess runs into Nottawasaga, entering that township in lot 9, concession I. This recess contains a large Algonquin island of some 2,000 acres in extent. On the side of this island facing the south-west is a very strong cutting which extends four miles from near Glencairn to a point south-west of Cashtown, where the island ends. Abundant gravel beds lie beneath the surface.

Avening and Glencairn. The district around Avening and Glencairn is several feet lower than the Algonquin beach and the Pine plains in front of it, and may have contained a small inland lake for some time after the period of the Algonquin; this tract is now drained by Mad river. Good fertile soil is found in the supposed former lake bed. Mad river has cut a canyon through the Pine plains. In lot 33, concessions II. and III. Tosorontio, the canyon contains terraces, showing an intermittent character in its excavation. Where the branch of the Mad river that comes out of Mulmur, crosses the 7th line of the township in lot 28, there is a distinct terrace 40 feet above the Algonquin, in the canyon or valley.

On the south-west side of this recess in the escarpment, *i.e.* S.W. of Avening, a tract of very high ground juts to the east, and is visible, standing out by itself, for a long way. Otherwise described, the Avening recess is bounded on the S.W. by projecting high ground, immediately south of which is another recess in which Randwick and other places in Mulmur, are situated. But the Randwick recess does not contain any Algonquin bay, although the shore-line about 160 feet above it, extends far into this recess, and makes some islands lying within it.

South of the Randwick recess, a projection known locally as the 'Oak Ridges' runs out from Mulmur, beyond the 2nd line of Tosorontio. Its margin, as just defined, is the 160 feet shore-line, and the Algonquin itself, is some two miles farther east. The name of this projection is derived from the timber which prevailed upon it, but which has since been removed, yet countless young oak trees are now to be seen on the high ground. The southern faces of the Oak ridges, are very steep and sandy, the material having been washed over by a strong and higher water, whose surface would be some 230 feet above the Algonquin. Another conspicuous recess along the south of the Oak ridges, runs far into Mulmur. Oak ridges.

THE PINE PLAINS.

Starting from the apex of Cornhill, in Sunnidale, the Pine plains extend in a S.E. direction, and cover portions of three townships. In shape, the plains have the outline of a beaver tail with a length of ten miles, and a breadth of seven miles at the widest part, and form an immense sand-pit of the Algonquin, with perhaps a little subsequent alteration by winds. Yet wind-blown sand is not commonly seen over this tract. The Pine plains were covered originally with a red pine forest, which was removed many years ago, and the land being too poor to cultivate, they are again thickly covered with a second growth of that timber. Pine plains.

Crossing the Pine plains along the town-line between Sunnidale and Tosorontio, we find the land unoccupied and unfenced from the end of the line near Glencairn, for some miles eastward along the Tosorontio side, or as far as the 7th line of that township. On the Sunnidale side there is a conspicuous range of sandhills, about half a mile from the road and almost parallel with it. These sand hillocks run through concession I, Sunnidale, and all the way through lots 6 to 11, beyond which the range passes out of Sunnidale at about lot 12, into Tosorontio at lot 33, concession VI. In the former township a few settlers have located here and there along the town-line. This range of sandhills is doubtless the main axis of the whole spit from Cornhill, though it seems to have been deflected a little to the leeward side of that locality and comes more directly, in appearance, from the large island near Cashtown. This axis of sand dunes is the part of the plains that has a more wind-blown appearance than any other, and in this respect it resembles the much higher range of sand dunes near the mouth of Nottawasaga river, the latter being the product of a lower strong shore-line. Crossing the Plains by the road from Lisle to Angus, we Sandy lands and ridges.

find along the eastern edge of the Plains, near the latter, lake terraces, made by shore-lines lower than the Algonquin.

Travelling southward from Angus, the sand continues until the West Essa ridge is reached, six miles distant. For about a mile after leaving Angus, the surface of the land looks as if the sand had been drifted by winds.

Shells at Angus.

No shells or other organic remains have been found during my excursions or observations on these Plains. The shells collected by Prof. Chapman at Angus (Geology of Canada, 1863, p. 910), and by Prof. Coleman (Trans., Canadian Institute, vol. VI., 1899, p. 40), were taken from the lake beds of lower and more recent bodies of water than the Algonquin, whose shore-lines are mentioned in the preceding paragraph.

UPPER CANYON OF THE NOTTAWASAGA RIVER.

Canyon in the Algonquin.

Through Tecumseth and Essa the Nottawasaga river, for 20 miles along its course, has cut a canyon in the deposits made by the Algonquin, thus affording good sections. The silted plain—the bed of the ancient Georgian bay near its head—has been given different names in different parts; but the Essa Flats is the term applied to the greater part of the land through which this canyon has been made. Usually, the course of this canyon is too far from the shore-line itself to contain any stones or gravel; at any rate, I have observed nothing but stratified sands and clays at the places mentioned below. The superficial deposit is almost always a reddish sand. Beneath this, to a depth of several feet, are beds of a whitish or gray sand, which gradually becomes finer as one descends through the layers. This finally passes into clay, and in the lower parts of the canyon it becomes a stiff blue clay. The latter is impervious to water, so that along the low parts in the canyon, water oozes from the layers of clay and trickles down to the river. Of the many beds exhibited in the sides of the canyon, each layer may indicate a year's growth of the deposit, the horizontal planes of cleavage showing the effects of winter or ice-covered periods. The entire deposition of material, passing from fine blue clay at the bottom to coarse sand at the top, shows unmistakably a falling water surface.

Depths of canyon.

At the river bridge, on lot 5, concession VI., Essa, the canyon is 60 feet deep. There is a projection or shelf on both sides of the canyon, which may be seen in lots 6 and 7, sixth line, Essa. On the No. 10 side road, Essa, which the river crosses in its west half, concession

V., the canyon is again about 60 feet in depth. There is a terrace in it 35 feet above the river, or about 25 feet below the top of the canyon. A branch that flows into the river near this point has also cut a canyon to a depth similar to that of the river. At the No. 15 sideroad, which crosses the river in the eastern half of concession V., the layers are finely exhibited. At the No. 25 sideroad there is a terrace at 20 feet below the top of the canyon. The river itself runs in a 15-feet channel at the bottom; that is, a canyon within a canyon. It would thus appear that a second terrace is forming. The canyon here is altogether about 75 feet deep to the surface of the river. This is near the deepest part of the cutting. Before the next sideroad is reached below, the land drops many feet and newer lake shores are marked against the face of the cutting.

Resuming our journey along the Blue Mountain escarpment, which this digression to examine the upper canyon had interrupted, the next prominent feature we reach is the West Essa ridge. It formed a long peninsula during the time of the lower or main Algonquin waters, projecting seven or eight miles outward from the line of the escarpment. The isthmus lying behind the ridge and connecting it with the escarpment consists of low land, but the lower Algonquin water line does not pass south between the ridge and the higher hills in Mulmur, although the upper Algonquin, at 40 feet above the lower, appears to do so. This West Essa ridge divides the wide valley that contained the ancient head of Georgian bay into two parts, about equal in breadth, although in length they differ greatly. The village of Everett is situated at the head of the western or shorter arm, just as Angus lies at the head of the lower or Great Nipissing series of shores. Algonquin features on the Blue mountain.

Small ridges or corrugations, with a north-west and south-east direction, occur on this West Essa ridge at lot 10, fourth line, Essa. These resemble the ridges of Cornhill and the Oak ridges in having this exceptional direction, viz: jutting up the valley, as if forced into this shape by ice. The adjacent flat formed below the Algonquin level has already been referred to under the head of the upper canyon. There is evidence that these wide tracts of ground, silted up by the Algonquin water are fossil-bearing. About the year 1898, some fossil unios, fish bones and pieces of wood or bone were found while digging a well on the Agnew farm, east half of lot 4, concession 3, Essa. Fossils.

Along the east edge of this narrow part of the ancient Georgian bay, the Algonquin made a row or chain of some half dozen islands. They stood near the eastern shore of the water and extended from Ancient islands.

Egbert in Essa southward as far as Thompsonville in Tecumseth. One or two at the north end of the chain were cut off from the mainland by only the upper or high water Algonquin.

Projections.

Another projection extends out of Adjala, a short way into concessions 12, 13 and 14 of Tecumseth. Between this projection and the last (the West Essa ridge) a deep recess runs into the face of the escarpment, with an island at its entrance. This spur into Tecumseth shows much erosion on its north side and much filling on the south side. Along the town line, between Adjala and Tecumseth, opposite the 12th and 13th concessions of the latter, the hills are covered with a deposit of sand for 40 feet and more above the lower Algonquin. On the same town line, from the 11th to the 12th line of Tecumseth, wave-built sand ridges, a mile in extent, occur. This chain of ridges looks like the remains of a sand spit issuing from the corner of the above-mentioned spur of high land. But the Nottawasaga river, which runs close to the spur, seems to have cut away that part of the spit nearest the land from which it was derived. A long arm passes down the south side of this spur and runs far into Adjala. It is known as the Adjala Swamp, and the lowest Algonquin shore line is well marked along the sides of this swamp and entirely around it. A very strong example of the main Algonquin cutting occurs in lot 22, sixth line, Adjala, although this is far inland.

Skeleton of a mammoth.

On the Haffey lot, west half lot 14, concession VI, Adjala, J. Henry Peck of Stanley, N.Y., found, in 1887, parts of the skeleton of a mammoth. This is the only instance known to me of mammoth bones having been found in the Georgian Bay basin. One of the molars is in Elmira College, N.Y. The other bones are in the Geological Museum of Lafayette College, Easton, Pa.

At this southern extremity of the ancient Georgian bay, the other bifurcation passes to the north-east for a long distance through Tecumseh, West Gwillimbury and Innisfil. The ridges on the land bordering this long sweep, commencing at Bailey's creek in Adjala and passing along both sides of it, are regularly disposed toward the north-east.

In Tecumseh and Adjala.

At Beeton on No. 10 sideroad, another recess occurs occupied by a considerable stream, running to the south-west. In this vicinity, and through Tecumseth generally, and in part of Adjala, the upper Algonquin, at 40 feet above the lower, is a strong shore-line, and the land in the zone between the two shore-lines shows a large amount of washing and flooding. In the time of the upper Algonquin level of 40 feet above the main Algonquin, the Georgian bay had a much further exten-

sion southward in many places hereabout, than during the latter. Where the No. 15 sideroad crosses the main Algonquin, there is a well developed water-cutting a few rods south of the ninth line. A mile south of this much of the land was washed by the 40 feet higher Algonquin.

Farther east, at No. 5 sideroad, West Gwillimbury, on the north half of lot 5, concession XII, the Algonquin is a wave-built shore. Sand-blown reefs also occur here. A curious little stack-like island occurs in lot 5, concession XII. The Hamilton Branch Railway follows the Algonquin beach for two or three miles, through Tecumseth. A shore-line is visible in a narrow ravine at No. 5 sideroad, third line, Innisfil, and it also occurs on the north half of lot 6 in concession II. At the latter place, it is so well marked, with a much washed plateau or water-plain beneath it, that its identity with the Algonquin high-water (40 feet) cannot be mistaken. Looking north-east from the second line, this water-plain is so strong throughout lots 7 and 8 that it is clearly seen to be the early or upper stages of the Algonquin. Another similar water-plain, with gently rolling surface, occurs in lot 11, concession V.

West Gwillimbury.

There is a distinct bar, higher than the main Algonquin, across the valley of Bear creek, near the fourth line, Innisfil. This bar crosses the entire valley, with the exception of an outlet or break of 40 rods at the west side. But the streams do not now go through this outlet, having made another breach farther east. This bar shows a perturbation of some kind in the rate of subsidence of the Algonquin waters. In fact, the bed of this entire arm, some 20 miles in length, all silted up to within a few feet of the main Algonquin, would amply repay a more detailed study than I have been able heretofore to give it, and would show the phenomena of the subsidence, better than many features in other parts of its course.

Bars of sand.

Another low bar across this valley at the north half of lot 12, concession V, Innisfil, is one of importance, as it is the watershed of the stream flowing north and south. Hewson's or Beaver creek flowed northward through this valley into Kempenfeldt bay, but the Algonquin shore-line did not pass through it, although the 40 feet one may have done so. In any case, the bed of this brook was flooded land in Algonquin times, even if its altitude should prove to be a few feet higher than the main or lower shore-line. This flat, like others, shows a record of the subsiding stages of the Algonquin.

Returning now to the channel that divides the mainland in South Simcoe from the archipelago in North Simcoe—the Colwell and Barrie

The Colwell and Barrie channel.

channel—where we left it some time ago, we find that along the south side of this channel the Algonquin is chiefly wave-built and is not now conspicuous, as the sand of which it is formed is loose and changeable. The first hill south of Allandale is a sand spit, except at its base. It is perhaps a little wind-blown, especially toward the top. Eastward from Allandale, there is an extensive deposit of gravel lying across the recess now occupied by Whiskey creek. The Northern Railway Company used these gravel beds as ballast for many years. The creek itself has cut a canyon through the deposits to a depth of some 50 feet. Similar canyons have been cut farther east by Hewson's or Beaver creek, and by Hewitt's creek, both of which flow northward into Kempenfeldt bay.

Most easterly extension of the Algonquin.

The most easterly extension of the Algonquin in this part of the county, viz., near Big Bay Point, is not so sharp a projection as the present shore of Lake Simcoe, but there is evidence that a considerable part of the old promontory was crowded away by the Algonquin water which being larger was much more active than the present Lake Simcoe. Along the south side of Kempenfeldt bay, the Algonquin is a cut-terrace most of the way.

Southward, at the seventh line, a little north and west of Nantyr, a well marked example of the 40 feet higher or upper Algonquin is seen. In a few places immediately south of this, the shore-line next above the main Algonquin passed through channels into the long arm of Bear creek, westward. In one of these cross-channels south of Churchill, in the third concession, many ice reefs may be seen on lot 16, looking as if small glaciers had lain in the valley and left miniature moraines.

Bradford.

The Northern Railway (a branch of the G. T. R.) follows the Algonquin beach for 12 miles northward from Bradford. Another long arm extends several miles southwest from Bradford, and is drained by the Holland river. This arm is much silted up, tha upper deposits being the reddish sand so peculiar to the Algonquin lake bed. The Algonquin beach leaves Simcoe county in this arm, but it may be observed that through the northern part of York county it makes a series of long arms like those in Simcoe county. This will conclude our survey of the shore-line in this direction.

THE INSULAR TRACT IN NORTH SIMCOE.

Archipelago in North Simcoe.

The Algonquin lake in North Simcoe contained an archipelago of large islands. We shall make a tour around this island group, beginning at Barrie and passing west, then north.

In a sand pit on Anne street, Barrie, there are waterlaid sand deposits, for fully 30 feet above the Algonquin, with apparently ripple marks in the sand layers. These deposits are probably due to the upper Algonquin, some faint traces of which appear on the surface in the neighborhood, a little higher up than the deposits. When sinking artesian wells in this town, which are readily had anywhere below the Algonquin level, the same story is always told by the materials passed through. These are coarsest at the top and shade into finer, as one descends, until at a certain depth, varying according to locality, but 68 feet at the town waterworks, the finest clay ends. This order indicates a falling water surface in which the materials were laid down, in accordance with the rnle furnished by common experience.

At the west end of the channel that divides the Algonquin mainland in South Simcoe, from the above insular tract in North Simcoe, a great spit of gravel shading into sand, runs out from the shore-line where it bends northward at the 12th line of Vespra. This spit runs southward as far as Colwell station, and it is commonly known as the Colwell spit. In the low ground a little east of the spit, some red sand or marl is found interlaid with layers of grey marl. West of the spit the land remains high, nearly level with the top of the spit. The railway company (G.T.R.) has a large gravel pit in these beds. **Dividing channel.**

From this place northward through Vespra, then eastward, there is a continuous cutting some seven miles in length. This cutting continues to increase in depth all the way from near Colwell, until at or near the 9th line of Vespra it attains its maximum. Here it is a little more than 200 feet in height above the terrace at its base, and as steep as its clayey materials will permit. It would be difficult to find among shore lines, ancient or existing, a finer example of shore cutting. It faces the north-west, and evidently received the full force of the Algonquin lake or sea from that direction, the sweep being unbroken from beyond Port Arthur on the present Lake Superior to this point. **Vespra.** **Great sweep of water.**

The materials dragged down from the cliff by the active shore-line have been chiefly deposited under the old water line in an immense filling. This has a width of half a mile or upwards in a few places. The cutting has been so extensive that all the shore-lines immediately above the Algonquin have been completely worn away. But in lot 15, concession VIII., Vespra, at the edge of an Algonquin bay, about half-way up the cliff, or rather more, a fragment of a strong lake terrace is to be seen at about 160 feet above this shore-line. It is quite conspicuous, as it enters the bay, but further outward it is completely worn off.

Midhurst.

Eastward from this locality plains extend for a few miles, similar to the Pine plains in Sunnidale and Essa, but smaller. These are situated chiefly in the Vth and VIIth concessions. Their formation is gravelly, and a road leads along their highest crest from Munro's creek to Midhurst, a distance of about two miles. The source from which this extensive deposit of Algonquin materials was taken was evidently the high cutting farther west. Some prominent sand dunes are to be seen in concession IV on lots 14 and 15, the materials of which have evidently been drawn from the same source, but being finer they have been carried farther. An exposure in Algonquin deposits on lot 10, seventh line of Vespra, shows a marly substance interstratified with sands. These deposits are Algonquin materials washed to leeward from the top of a hill north-west of the place.

Willow creek.

The lower or main Algonquin beach extends a long way up the valley of Willow creek into Oro township, and the upper or 40-foot beach much farther. High ground bounds the east side of the Willow creek in Vespra, and against this the Algonquin water made a cut-terrace all the way. This extends northward and eastward as far as the lot 30 sideroad in concession II. A gravel spit is thrown from this across the opening into another bay eastward.

Near Craighurst on the Penetanguishene road, the land has a washed and levelled character for many feet above the main Algonquin, as high up as the 40 feet shore-line. It resembles some examples in the south and west of the county where the lake is better developed than it usually is in the 'Insular Tract' of North Simcoe. The steepness of the hillsides appears to be the cause of the difference.

Various ancient islands.

The south-west end of the first large island to the left comes into the north side of Vespra, and presents some interesting features. In the east half of lot 2, concession VI, the shore-line has diffuse gravel spits or deposits. Crossing over to the other side of this island's extremity, on the townline between Flos and Vespra, on lot 8, concession I, Flos, there is a desert of sand dunes. But the main Algonquin, a little further west, is quite distinguishable by its water-bearing character on lot 9.

From the extremity of the island farther east, there runs to this place a spur, which the Algonquin did not completely wash away, but made breaches through it. This chain of remaining fragments is higher than the main Algonquin, which is clearly marked along the south face of the broken spur. Its boulder belt is quite wide and at 60 feet lower, there is a deposit of the usual red sand. The latter is on the sloping

land southward. This worn chain extends through lot 2, concession VI, and the shore-line itself runs westward a few rods into lot 2, concession VII.

Following the west shore of this island northward into Flos, a break is found in the island in the IIIrd concession. At this place it is divided into two parts by the upper Algonquin, but not by the lower. Here, the upper went through lots 1, 2 and 3, concession III, Flos, and a resulting sand plain, showing much flooding, passes through these lots. The south edge of this channel was near the third line, and the north edge near the fourth line. A little to the north-west from the western entrance to this channel, viz., half a mile north of Fergusonvale, there are deposits of the red sand at about the usual interval of 60 feet below the lower beach. Township of Flos.

Along the fifth line, running far into the ridge of high land on the northern part of the island, there is a gully or deep recess extending as far east as the Base Line, and containing the upper Algonquin. Immediately north, there is a conspicuous feature of the shore-line, in lot 4, concession V, in the shape of a prominent nose or headland extending further west than the general course of the shore-line. Its sides are bold and cliff-like. There was a submerged bar or low ridge running out from the last mentioned headland, which at the present time appears to form a watershed between the drainage to the Nottawasaga river and that to the Wye. The bar is to be found on lots 3 and 4, concession V, Flos. Features formerly submerged.

In the more westerly parts of Flos, some submerged features of the shore-line are worthy of our attention. There is a considerable train of boulders, running for about two miles through lots 12, 13, 14 and 15, concession III, Flos, in a north-easterly direction, the usual course of the ridges in this county. On close inspection, this train is seen to be the top of a former ridge, which was washed over by the Algonquin. The ridge, as it now stands, is a few feet below the Algonquin water-line. South-eastward from this ridge, heavy sand deposits are to be seen, which were evidently worn off its summit by the Algonquin water. Through these deposits, Marle creek has cut a considerable canyon.

There is another, though less prominent ridge of boulders mixed with clay, on lots 15 and 16, concession IV, Flos, which also runs to the north-east. The same low ridge, with its water-holding clay-beds mixed with some boulders, is also observable on another road, viz., on the north half of lot 17, concession III. This was evidently the crest of another ridge, the stoniest part of it having been the main crest in Ridges.

Algonquin times. South-eastward from the crest, the usual sand deposits are to be seen. To the north-west, the materials are first a fine sand, which soon shades into clay, the land sloping gently toward the north-west. Another stony crest is seen on the north half of lot 15, concession VI, near Crossland, from which the land again slopes gently north-westward.

Bouldery crests.

The bouldery crests that we have just been passing in review are evidently the highest parts of a considerable ridge running through this westerly part of Flos, but the Algonquin waters had planed off all the irregularities of its surface. A little to the eastward of the crest above mentioned, I observed the deposits of red sand on the eighth line, opposite lots 8 and 9, situated at the usual depth of 60 feet below the waterline of the main Algonquin beach. In some respects this water-planed ridge through western Flos is a continuation of one running through the township of Sunnidale, which has the same altitude as the Flos part of it, viz., within a few feet of the Algonquin shore-line. The Minesing hill in Vespra also comes under this class of phenomena. It has a boulder train a little south of Minesing village, eastward from which, about a mile, there are immense deposits of gravel, carried out of the crest and thrown over the leeward side of the shoal, while the ridge was actually in the Algonquin water. The last mentioned gravel deposits are crossed on the road from Minesing village to the station. All these crests in Sunnidale, Flos and Vespra, and some in Tiny, as we shall presently see, show the enormous force of the Algonquin lake in washing off the tops of so many shoals, and the large amount of work done by that body of water in the transportation of materials.

Minesing hill.

Question as to ice-covered surface.

On water-worn ground like that we have just been considering, the country assumes a very gently rolling aspect, and in some places it becomes nearly a dead level. No sharp glacial features are left on land that has been washed over by so powerful a physical agent as the Algonquin lake, but many phenomena show that the Algonquin was followed, as well as preceeded, by an ice-covered surface, but at the time of the greatest action, and the cutting of the enormous shore-line itself, the surface was tolerably free, at least from ice of a thickness great enough to leave many enduring marks.

Ridge with boulders.

On the No. 18 sideroad, half-way across the IVth concession, Tiny, there is another washed ridge with a crest of boulders. Northward on the same road, half a mile, at the crossing of the 5th line, there is a sand-plain with small sand dunes from another washed crest further northward. Another series of washed crests occurs around St. Patrick.

This is the top of another ridge, distinct from those I have described, and also distinct from the high Algonquin island a little eastward, known as the 'Mountain.' As one passes north on the No. 13 sideroad, he first encounters the washed boulder trains half-way across the VIIIth concession, and they continue northward for four miles, with but two interruptions. The first stony tract continues north for two miles, viz., into the Xth concession. Afterward, a continuation runs north of the eleventh line and there is another boulder-crowned ridge between the eleventh and twelfth lines, the stony pavement continuing northward of LeFaive's School on lot 13, concession XII. These boulder trains run in the usual direction, viz., north-east. They were evidently shoals in Algonquin times. The boulders cease altogether, half way-north in the XIIth concession, and there the sand begins.

A high gravel ridge lying some distance off the 'Mountain,' from which it is separated by Lannigan's lake, begins on lot 9, concession II, and runs north-east. It looks like a large spit; at any rate, the materials of which it is formed are lacustrine, not glacial, and they probably came from the boulder tracts toward the south-west that we have been considering, rather than from the 'Mountain.'

The 'Mountain' was a high island in Algonquin times. There are boulder pavements around the greater part of it, especially along the south and east sides, where the boulder belt is broad. There is a steep descent or cutting of nearly 250 feet at Bateson's, on the north side, through lot 108, concession II. The 'Mountain.'

We come now to the three large outer islands of Algonquin times, and it would be hard to find more interesting features than these in connection with ancient lake phenomena. Like the 'Mountain' just mentioned, they are all encircled almost completely by cuttings. These cuttings attain a remarkable height in some places; along the S. E. face of the Randolph ridge, the most southerly of the three, a cutting has a precipitous height of about a hundred feet, the slope being as steep as the clayey materials will admit. Still further, the outlines of all of them have a smooth, rounded character when correctly delineated on a map, (i.e. the protuberances of land were all worn off), as compared with the shore-line in other places, where bays and projecting points of land are common. Three outer islands.

Along the south side of the Randolph ridge, there is a broad shelf made by the shore-line. Vent's road, deflected to join with the thirteenth line, passes along this shelf and affords a good view of the 'lake-cliff.' On No. 13 sideroad, in the north half of concession XIII, the strong

cutting has beneath it a boulder pavement running half a mile south to where the sand beds occur.

Westernmost island. The westernmost of the three islands mentioned above extends for some distance north of Ste. Croix, and I will call it the Ste. Croix ridge. It is a little more than a mile in length. There is a strong terrace around the whole of the island, and immediately west of Ste. Croix, on the 18th line, the boulder pavement is very extensive. One cannot witness this phenomenon without being struck by the enormous amount of lake shore action that was necessary to form this boulder tract. South of Ste. Croix the boulders extend for half a mile, i.e., half way across concession XVII. At the north end of the Ste. Croix ridge, on lot 18, concession XX, there are sand reefs and boulder pavements.

Effects of currents. The three large islands just mentioned lie, with respect to each other, at the corners of a triangle. The intervening space partly inclosed by them contains a network of immense sand bars, formed by the currents and counter currents passing through the group. This is a very interesting phenomenon in connection with a study of the circulation of currents amidst islands, and the formation of sandbars. These bars all have lengths of two or three miles, according to their positions. One runs from the north-east corner of the Randolph ridge toward the little island lying off the most northerly of the large ones. The course of this bar is almost due north and south. At the corner of the seventeenth line and the No. 8 sideroad it makes an extensive sand plain. Another runs from the same extremity of the Randolph ridge in a north-westerly direction, towards the centre of the space between the islands. This crosses the seventeenth line at the boundary between lots 12 and 13. On the same line, at the boundary between lots 15 and 16, where a by-road leaves it for Thunder bay, the summit of another bar or watershed is found, which has passed diagonally through lot 17 from the Ste. Croix ridge. Two bars or divides join here, namely, the one just mentioned, which continues south-east to the Randolph ridge, and another from the extremity of the large island to the north-east.

Horseshoe island. An Algonquin island in the township of Tay presents some interesting features. In shape it is not unlike a horseshoe, and it incloses a marsh of about 75 acres in lot 86, concessions I and II. An Algonquin spit extends across the open side of the shoe, and it doubtless shut off in this pocket a small extinct lake. The Algonquin beach is a strong shore-line within this bay, on lot 87, concession I. The north-east face of the Horseshoe island was much washed off by the Algonquin waters. The resulting tract of stony ground near Elliott's Corners has an extent of two miles, and is quite swampy, although covered with a pavement of boulders.

The next two islands, southward, lie close together. The channel between them is now occupied by a branch of the Hogg river, the course of which, as well as the channel, is almost due north and south. The north end is the wider of the two. Across this end there is a gravel spit and wave-built formations extending for the two miles by which the islands are separated. The gravel spit is in lot 3, concession III, Tay, and it is cut through by the Hogg river. Two islands.

Into the westerly of the two islands last mentioned, which is kidney-shaped, a bay of the Algonquin runs inland near Waverley, opening toward the north. This bay or pocket extends across the boundary of Tay into Medonte, on lots 75 and 74. The shore-line it contains appears to be the 40 feet Algonquin. The townline crosses the sandy bed of this bay, and through the bed run streams at some seasons of the year, but they are dry in midsummer. Northward the plateau of this bed soon drops about 50 ? feet to the lowest strands of the Algonquin at Dawe's creek.

Off the north-east point of the large Algonquin island, the most easterly of the two just considered, there is an extensive patch of boulders, viz., on lots 5 and 6, concessions VI and VII, Tay. The denudation of earlier formations here was enormous. Similar tracts of denuded boulders lie at the north-east of the next large island to the eastward of the last. In fact, the sides of the islands exposed to the north-east all show an immense force of the waves coming from that direction. This is true along the whole line of this row of large islands, where they face the north-east. Great denudation.

The last named island, which I have called the Rosemount ridge in my archæological reports of these townships, has a total length of 12 miles. On this island, along the Xth concession of Medonte, lots 17 to 20, the ground everywhere above the Algonquin, as high up as the 110 feet shore-line, is very much washed, and there are some sandy tracts, perhaps the result of the washing, as elsewhere. At the south-west extremity of this large island, a spit issues from it in the Ist concession of Medonte, about lot 48 or 49. It consists of gravel, nearest the ridge, and gradually shades into sand. The Sturgeon river makes its way through the sandy part of this spit. Some sandy hillocks are to be seen west of the river. Lying off this large island in the Coldwater river valley a small island of some 200 acres is quite prominent, chiefly in the VIIIth concession. Rosemount ridge.

The next in order, Algonquin island, which is by far the largest of the whole group, covering some 120 square miles or more, is a complex congeries of ridges. At the N.E. extremity of this large island, near Largest island.

the village of Warminster, a very strong cutting is found along the north edge of the ridge, through lot 10 in the XIth, XIIth, XIIIth and XIVth concessions of Medonte. It passes into the township of North Orillia in lot 9.

Bays in the large island.

Near Coulson, a considerable bay of the Algonquin lake runs some distance south into the large island. The most southerly reaches of this bay are occupied by the upper Algonquin at about 40 feet above the main Algonquin beach. The upper one here has the same character as in other parts of the county, being the general limit to which the washing extended. An enormous spit of the main Algonquin occurs on the northern part of lot 4, east half of concession VII., Medonte. It juts out from the high ground at the east side, along the face of which there is a great cutting. The spit runs nearly across the mouth of the bay just mentioned. Immense sand plains occur here in the old bed of the Algonquin lake, extending from the vicinity of this spit to the small island above mentioned.

Another bay runs south along the island between concessions III and IV, into Oro township. At the west side of the entrance to this bay, in the east half of lot 2, concession III., Medonte, two shore-lines are visible at 40 feet and 70 feet above the lower or main Algonquin. A little distance westward the main Algonquin emerges from beneath the debris and becomes, as usual, marshy along its course, with very strong springs issuing here at its water-line.

Strongly marked shore-lines.

On the second line in both North and South Orillia, and westward of Marchmont the higher shore-line at 40 feet above the lower, and even the one at 70 feet, are strong, and show a large amount of wave action, like all the shore-lines along the north-eastern faces of these islands. An example of great washing action, leaving a gravel hill-top, occurs a few rods east of Marchmont village on the crossroad. Altogether, in the Marchmont district, the parts of the Algonquin become much differentiated, and it is no easy task to identify the main shore-line everywhere. The collateral shore-lines, both above and below it, introduce elements of confusion, but there are certain places where it is well defined, and by reference to these places it can be distinguished from all the others.

Archipelago in Orillia.

There was an archipelago of Algonquin islands, smaller than those we have been hitherto examining, in the townships of North and South Orillia. The outermost has a length of three miles, and has a very strong cutting around it, especially in concessions VI, VII and VIII, of North Orillia. The land on this island is very stony and much washed, both above and below the Algonquin; but the strong cutting

of the main Algonquin is unmistakable, and easily distinguished by its strength from the other shore-lines. It attains an altitude here of about 155 feet above Lake Couchiching, or about 875 feet above sea-level. The uppermost shore-line in the series below the Algonquin, sometimes known as the 'Great Nipissing Series,' becomes a strong shore-line in these outlying parts, at about 60 feet below the Algonquin.

Double shore-lines.

On the No. 9 crossroad, South Orillia, there is a strong Algonquin cutting a few rods west of the third line. The shore-line here is distinctly double on the same hillside, the upper showing out well at about 40 feet above the lower. It is also seen to be double south on the 2nd line in lot 11; and both strands are distinct in lot 10, looking south-east from the corner of the 2nd and 9th crossroads. On the west half of lot 21, con. XIV, Oro, the next lower shore-line is well cut at 60 feet below the main Algonquin. From near this place, the Grand Trunk Railway follows close to the Algonquin for nine miles, to the IVth concession of Oro.

GENERAL CONCLUSIONS.

General conclusions.

Upon the whole, I do not see much reason for calling the Algonquin, a glacial lake, as many writers do. Farther inland, i.e. westward, it might have been semi-glacial, but in this part of the country (Simcoe county) the evidence proves exactly the opposite, viz., that but little ice interfered with its intense activity, although there were tranquil periods before as well as after it, during which there was thick shore ice of a sub-arctic character.

Ice dams.

The ice dam theory of Prof. Newberry has been extensively employed to account for Algonquin phenomena. But along the north-eastern parts, where the glacier or ice dam is supposed to have rested, and where the shore-line might be expected to fail to give us evidence of its presence, the drift deposits being necessarily covered up with the hypothetical glacier, it is just where the shore-line has its most distinct development.

Oscillations of climate.

The cause of the great strength of the Algonquin beach is a proper subject of inquiry, on the basis of our observations along the shore-line. Its formation and subsequent preservation would seem to have been the result of an oscillation of climate. If it had not been preceded by an ice-covered calm sea, as well as followed by a similar one, the record it left on the ground might have been different. The eroding edge of the water body had a chance to mark a strong line, which it did with great energy.

Perfection of preservation.

What strikes one most forcibly everywhere, is the perfection with which the superficial formations just beneath the level of the Algonquin shore-line have been preserved. Had the activity of the shore-line period been maintained as the water surface subsided, greater changes would have been wrought in the lake deposits of an earlier date. But we find them almost intact, just as the Algonquin water left them. Unless the subsidence was instantaneous, which is not at all probable, we cannot escape from the conclusion that a tranquil ice-covered sea succeeded the Algonquin for a long period. There are evidences upon the ground of such a sub-arctic period.

Difficulties in correlating different shore-lines.

These observations furnish us still further with evidence that here, within the compass of a single county, the character of the shore-line varies from other causes than the configuration of the land it met with. Its great strength along its north-easterly exposure contrasts with its less intense, though still strongly marked, features along the base of the Blue Mountain escarpment. How futile then are the efforts of some geologists to identify shore-lines found at different places, widely separated, not merely by the width of a county but by hundreds of miles. Supposed absence of shore-lines is accounted for by the presence of glaciers. Oscillations of climate may ultimately be found to be the safest guide in attempts at identification of shore-lines or their equivalents in different localities. When the climatical characters and other phenomena connected with shore-lines shall have been properly investigated, the superabundance of theories, mostly conflicting with each other, may be expected to resolve themselves into distinct knowledge.

An Investigation of the Copper-bearing Rocks of the Eastern Townships, Province of Quebec.

Principal J. A. Dresser.

Copper-bearing rocks of Quebec.

The time from June 23 to August 30 was spent in an examination of part of the copper-bearing rocks of the eastern townships of the province of Quebec. These rocks have received more or less attention from the Geological Survey since 1847, specially important reports having been made upon them by Sir William Logan in 1863, by Jas. Richardson in 1866 and by Dr. R. W. Ells in 1888-9. In these reports the copper-bearing rocks were shown to form three principal belts, having a general north-easterly trend in agreement with the main axes of folding of the Appalachian mountain system, which is here represented by the Notre Dame mountains. Throughout a considerable part of their known length these belts are about 25 miles apart and are themselves generally from 2 to 10 miles in width. The

most westerly has been called the Acton belt, the second the Sutton and the third the Ascot, from townships in which they are largely developed.

According to your instructions of May 27 last I was directed to examine a part of each belt with a view to eventually making a detailed study of the more important areas, and of determining their petrographical relations and extent as completely as possible. The Acton belt was first cursorily visited. Specimens of the country rock and of the intrusives which accompany the various deposits were taken at Wickham, Acton, Upton and Roxton. Three days were thus spent, in which I was much assisted by the Rev. L. C. Wurtele of Actonvale. The Sutton belt was next examined in a similar manner from Knowlton to the Vermont boundary line. The deposits at S. Sweet's, D. L. Smith's and the Sweet mine in Sutton, as well as the lesser mines on the south side of St. Armand Pinnacle were visited, and the main ridge of Sutton mountain, known locally as the 'Round Top,' was crossed in two directions. In this I was kindly aided by Mr. H. A. Honeyman, M.A., of Knowlton, whose familiarity with the geology of the locality was especially valuable. The eastern base of Sutton mountain between Glen Sutton and Mansonville was also examined in order to ascertain whether or not the copper-bearing rocks which form the western side, but do not extend to the more elevated parts of the mountain, re-appear here. It was found that they do not. Some extensive development work having recently been done at the mines in West Berkshire, Vermont, 4 miles south of St. Armand Pinnacle, a half day was spent in visiting them. These mines, which are the property of the Vermont and Boston Mining Company, repeat the conditions of the St. Armand and Sutton deposits and afford some of the best opportunities of noting the mode of occurrence of the copper observed in the study of the Sutton belt. I was courteously directed in visiting these mines by Mr. H. E. Rustet, Richford, Vt.

Localities examined.

The examination of the Ascot belt was begun at North Hatley, whence the Suffield, Eustis and Capelton mines were visited. Then after three days spent in the vicinity of Lake Megantic, to which reference will be made later, the Ascot and the Victoria mines near Capelton were visited, as well as some apparently smaller deposits on the east side of the St. Francis river. A camping outfit was then procured at Sherbrooke, and I was joined by Mr. A. P. Stevens, B. Sc., who had been assigned by you as my field assistant, and by Frank Graham, who was engaged as a general camp hand, and who also proved a most serviceable helper. Beginning in the fifth range of the township of Ascot Corner, the ridge of hills known as Stoke mountain

Camp outfit.

Other places visited.

was examined in as much detail as the nature of the country permits, to its eastern extremity near Dudswell pond, in the township of that name. The ridge between the St. Camille and South Ham roads, which forms the topographical continuation of Stoke mountain, was followed as far as Silver lake, and was crossed at various places for a distance of eight miles. Some copper deposits recently opened in the vicinity of Lake Weedon, were also examined at this time.

Sutton belt. The camp was broken up on August 17, and in the time remaining I proceeded alone to visit the more important of the known deposits of the Sutton belt in its northern extension in the townships of Leeds, Halifax and Chester. A reputed occurrence of copper at St. Nicholas, was also visited, and a few days were spent in the examination of some important deposits of copper-bearing pyrrhotite on the west side of Lake Memphremagog. This, with a few separate days spent at Melbourne, Upton and Ascot, completed the field work of the season.

The Acton belt. *The Acton Belt.*—The principal occurrences of copper that were observed in this belt were those long known at Wickham, Acton, Upton, Roxton and St. Pierre de Durham. The country-rock in all cases is limestone, generally in association with black shales or slates of sedimentary origin. Igneous rocks in the form of small dykes or irregular masses occur at all these places. They are intrusive in every instance as far as known, and sometimes themselves carry copper. The greater part of the copper, however, occurs in the limestone, or occasionally in the black slates, near the intrusives. The ores vary with the different localities. At Acton, bornite and chalcocite predominate, while at Upton, chalcopyrite and chalcocite are the chief ores, bornite being rare. Native copper is said to occur at the latter point, but I was not able to find any.

Similarity of intrusives. A feature of interest, as well as of possible importance, is the apparent close similarity between some of the intrusive rocks in the Acton belt, and the latest dykes which are found at the Eustis mine in the Ascot belt. In the latter case, however, the country-rock is a very old eruptive, and is itself the copper-bearer. The Acton belt, so called, is a rather ill-defined area in the Upper Cambrian and Lower Silurian systems. The distance from Durham to Upton, which are extreme points in the width of the belt, is about sixteen miles. From Roxton to Wickham, along its length, it is only twenty miles, but copper is known to occur further north-eastward at Drummondville, Wendover, Somerset, Nelson, St. Flavien, and, it is said, even at St Nicholas on the St. Lawrence river, over a distance in all of more than one hundred

miles. In the course of a brief examination of the St. Nicholas locality, I found no copper at all. An igneous rock similar in appearance to that which carries copper in the vicinity of Lake Weedon, in the eastern part of the Ascot belt was found, however, in considerable quantity. In the Acton belt on the west side of the St. Francis river there are also reported to be several smaller deposits of copper, as at St. Theodor d'Acton, St. Valerien, and in Danby, some of which are now receiving attention and are said to give considerable promise.

Geological positions of copper occurrences.

Although many of these copper localities are near the contact of the Cambrian rocks with those of Cambro-Silurian age, others, including some of the most important, occur within either formation. Hence they may be looked for anywhere over this long irregular area wherever intrusive rocks are to be found. The geological structure apparently gives no clue to the occurrence of the intrusives. The eastern part of this belt, between the St. Francis and the St. Lawrence rivers was, as has been said, not examined, except very briefly at the single locality of St. Nicholas. While it is not a region in which rock exposures are numerous, yet the rapid deforesting of the country in recent years and also the extension of the Intercolonial and the construction of the Megantic and Lotbinière railways should open some new parts of this region that may be worthy of examination. The high quality of the ores in this belt gives an especial incentive to the search for them.

Rocks of Sutton and Ascot mountains.

The other copper-bearing districts of the eastern townships are more closely connected with the geological structure of the region. In the reports of the Geological Survey for 1886 and 1894 three areas of Pre-Cambrian rocks, which in previous reports had not been distinguished from the intervening Palæozoic strata, were recognized, and their extent mapped. Two of these, the Sutton Mountain series and the Ascot or Stoke Mountain rocks, respectively include amongst their measures the middle and eastern copper-bearing belts of the earlier surveys. It is therefore a fundamental part of the present investigation to separate the copper-bearing from the other parts of these ancient rocks.

Copper ores associated with igneou rocks.

To this end two facts of prime importance have been thus far ascertained: that the greater part of these Pre-Cambrian areas are of igneous, not sedimentary, origin; and that copper occurs only in, or in close association with, the igneous rocks. The latter range from volcanic to plutonic in texture, and chemically they present both acid and basic types. All are highly metamorphosed and their original characters are often much disguised, if not altogether obliterated. Their intense foliation and shearing have commonly given the rocks which

are largely fine-grained 'traps,' the aspect of much altered sediments which they have hitherto been thought to be. On this assumption the ore bodies have been long regarded as bedded veins and so have been correlated on supposed stratigraphic grounds. In consequence of this change of view as to the character of the country rock, which a preliminary microscopic examination has established, such correlation becomes useless, and also any determination of the values of deposits based upon it. A brief notice of characters of some of these rocks was presented to the Canadian Mining Institute in March last (Journal Can. Min. Inst., vol. V, 1902) and to the American Journal of Science in July.

Pre-Cambrian of Sutton mountain belt.

The Sutton Mountain Belt.—The width of the Pre-Cambrian of this belt at the Vermont boundary line is about twenty miles, some sixteen of which are of volcanic origin. Copper occurs at many places in the volcanic portion, but is nowhere found, as far as could be ascertained, in the sedimentary strata. The latter include all the ridge of Sutton mountain, which consists largely of a gneissose sandstone, and so is entirely different in origin and lithological character from the main part of the large area to which it gives its name. The volcanic area consists chiefly of a dull green 'trap' rock, of fine grained and of rather uniform character. It is often amygdaloidal and is so far altered that chlorite, quartz and epidote are the principal minerals distinguishable by the naked eye. Its precise original character has not yet been determined. It has generally been described as chloritic slate. Quartz in veins and other forms is abundant in many places and sometimes occurs in close association with epidote. The latter forms nodules, which from their greater resistance to erosive forces stand out in prominent relief on weathered, or more especially on water-worn surfaces. These nodules are often found on closer examination to consist of alternate concentric layers of epidote and quartz. They are usually from one to three inches in diameter and sometimes make up as much as one-fourth of the entire rock.

Evidence of intense metamorphism.

In its unaltered state this rock was probably a rather basic one of the porphyrite or possibly of the diabase class. As the above description indicates, however, its metamorphism has been intense, and a detailed examination of the thin sections now being prepared will be necessary to determine its primary character as well as other important matters concerning it.

Certain smaller portions of the volcanic mass, however, are very different in aspect and also in mineralogical and apparently in chemical composition. They are light coloured, gray or fawn, and have a talcose feel

which is, however, probably due to the shreds of colourless mica (sericite) developed along the shearing planes of the rock. These are the micaceous and nacreous slates of the earlier surveys. Similar appearing rocks in the Ascot belt have been found by the aid of the microscope to be crushed and sheared volcanics which would have had about the character of quartz-porphyry when in an unaltered state. Copper seems to occur more frequently in these than in the chloritic rocks, although it is found in both. In the county of Megantic they frequently carry the rare mineral ottrelite, or chloritoid, which has given them a peculiar interest to mineral collectors. Several occurrences of the corresponding facies of this rock were observed in the Ascot belt where it passes by sharp transition into the basic volcanic already described. No field evidence to the contrary has yet been found in this area, so, pending a more complete investigation, the same relation is assumed.

Nature of ores.

The ores are chalcopyrite, bornite and chalcocite, with smaller proportions of blue and green carbonates, and they occur in a gangue consisting chiefly of quartz and calcite. They do not occur in true veins in any instance I have yet observed. Rudely lenticular masses seem common and frequently, either from the nature of the exposure or of the deposit, no definite form is discernible.

The volcanic portion of the Pre-Cambrian was found in the townships of St. Armand, Sutton, Brome, Bolton, Stukely, Ely and Melbourne, on the west side of the St. Francis river, and in Cleveland on the east side. In Chester, Halifax and Leeds, between 40 and 50 miles farther to the north-east, where the belt was next crossed, the rocks appear with the same characters as before. The reported occurrence of copper at many intervening points indicate that the traps are continuous in the interval. They have a width of about two miles on the St. Francis river, but, in Leeds, become as wide again as they are in St. Armand. The distance between these points is rather more than 100 miles.

Copper bearing localities.

Within that area over 300 localities were reported, in 1866, as copper-bearing, and some 23 as actually producing more or less ore. To this number a few more important occurrences have been since added. Some of these deposits have doubtless been worked out, or have proven unprofitable under the conditions in which they were worked, while others have been discarded on very superficial examination or inconclusive tests. For two seasons Mr. W. F. E. Bowers, of Chicago, has worked a new property on lot seven of the first range of Melbourne. At my visit in June last, a shaft seven and a-half feet square was sunk vertically to a depth of 50 feet in a quartz mass, which carried copper pyrites and bornite in stringers in the quartz through about one-quarter

of its width. Assays of the chalcopyrite were said to give 24 per cent copper, 32 per cent sulphur; of the bornite 19 per cent each of copper and sulphur. There was also $9 worth of gold to the ton.

Mines reopened.

Several of the previously worked mines in this belt have been recently reopened to some extent. Amongst them are the Ely mine in Ely, the Balrath in Melbourne, and some smaller properties in Shipton, Brome, Leeds and Chester. The Pre-Cambrian belt extends some forty miles to the north-eastward of the township of Leeds, but there was not time to make any examination of it. A few reported occurrences of copper in it would, however, indicate the continuance of the volcanic rocks, and the consequent promise of the area to the prospector. This is emphasized by the fact that the most important deposit yet worked in this belt, the celebrated Harvey Hill mine, now the property of Dr. Jas. Reed, occurs near the north-eastern limit of the township of Leeds.

Igneous rocks constitute Pre-Cambrian of Ascot belt.

The Ascot Belt.—The Pre-Cambrian of this area consists, in so far as it has been studied in detail, almost entirely of igneous rocks. Upon these there are occasionally found overlying remnants apparently of Palæozoic strata which once covered the entire area. They are chiefly ferruginous black slates common to the Lower Trenton formation and are found in places better protected from denudation.

The igneous rocks are essentially of the same types as those described in the Sutton belt, but their proportions are approximately reversed. In this Ascot belt the acid class—the micaceous and nacreous slates—greatly predominates over the basic type of chloritic and epidotic rocks. The latter present no features of difference from those already described that are worthy of note. In the acid class, however, there is a greater variation corresponding in some measure to its greater extent. This is chiefly in the degree of crystallization. While the main parts of these rocks are porphyritic in structure, there are both finer grained rocks and those of coarser texture. The former are unimportant in extent, as far as yet studied, but rocks of a more advanced stage of crystallization form large areas in Stoke mountain and also appear in various other places. These granite porphyries and porphyritic granites comprise a great part of the barren, or non-cupriferous areas, though in a few instances they carry important quantities of copper.

On the west side of the St. Francis river later dykes cut the other igneous rocks; and while the latter are extremely metamorphosed, the former are but little, if any, changed in position or chemical character,

Olivine diabase and comptonite have been found in an exceedingly fresh state, the latter cutting Lower Trenton sediments, as well as Pre-Cambrian eruptives. It is thus evident that this part of the Ascot belt at least has been the scene of volcanic activity at intervals through a long period of time, from Pre-Cambrian to Post-Trenton. Dykes were not observed in any other part of any of the igneous rocks thus far studied, nor has any other area of equal size produced as much copper as this part of the township of Ascot. While there is little but presumptive evidence that the greater metallic content of these rocks is due to successive and more varied volcanic action amongst them, yet the coincidence seems worthy of note.

Evidence of volcanic activity.

The Pre-Cambrian. as defined by the survey of 1886, extends from the east side of Lake Memphremagog, in the township of Stanstead, through Hatley, Ascot and Stoke townships and reappears after an interval of some 8 miles further to the north-east in the townships of Weedon and Stratford, and after a further interval again in Garthby. The position of the Garthby area, however, leaves it a matter of doubt whether it should be included in the Ascot or the Sutton belt, or whether, as is more probable, it forms a connecting link between them.

Petrographical relations of ore-bodies studied.

My examination between St. Francis river and Lake Memphremagog was made chiefly to ascertain as far as possible in the working mines the petrographical relations of the ore-bodies, and hence it did not extend into the township of Stanstead and only included the northern part of Hatley. Here the Pre-Cambrian was found to be largely, if not wholly igneous. Also on the west shore of Lake Memphremagog the basic volcanics again occur, having a width of nearly a mile and a half south of the Mountain House landing. They form the base of Owl's Head mountain. Four specimens described by Dr. F. D. Adams in the report of the Geological Survey for 1880-1-2, (pp. 11, 12 and 13A), appeared to be from this locality. They were altered diabase. The area is densely wooded along the lake shore and time did not permit of an examination further to the westward. The extension of the Ascot traps across Lake Memphremagog, thus brings the rocks of that belt within eight miles of the Sutton belt; whence it is not improbable that these belts may yet be found united at either end, the Ascot belt forming a chord seventy miles in length, which reaches the Sutton belt at two points about one hundred miles distant when measured on the arc it describes. The occurrence of these rocks on the west side of the lake, also adds to the otherwise promising prospects of this as an important copper-bearing district.

Of the importance of the area between Lake Memphremagog and the St. Francis river, I may quote from the Report of the Geological

Survey for the years 1888–9 in which this belt from Hatley to Stoke is described in detail by Dr. R. W. Ells, who mentions that of fifty-five copper localities, thirteen were actually working in the year 1865.

Report of Dr. Ells quoted.

Concerning these deposits, Dr. Ells said: 'It may be very safely predicted that the real value of many of the mines which were opened twenty-five years ago and speedily closed has never been ascertained, and that masses of ore of equal importance to those so long worked will at some not distant date, by careful prospecting be found. Much of the failure of twenty-five years ago was doubtless due to the speculative character of the work done. Mines were bought and sold on the flimsiest sort of evidence as to their value or worthlessness, often on samples which were obtained from an entirely different location from that represented. The growing importance of these ores as a source of supply for sulphuric acid is being very fully realized by the men interested in this industry in the United States, their superiority over most of the ores there found, for this purpose, being acknowledged.'

Besides the well-known and extensive works of the Eustis Mining Company at Eustis, and of the G. H. Nichols Chemical Company at Capelton, the principal work more recently done has been at the group of mines at Suffield, the Ascot and the Sherbrooke mines.

Acknowledgement.

I am specially indebted to Mr. John Blue, manager of the Eustis mine, who most courteously extended every facility for a complete examination of that extensive mine.

toke mountain range.

Stoke Mountain is a series of hills some three to five miles in width which rise gradually from the St. Francis river opposite the city of Sherbrooke to a maximum height of fifteen hundred feet above Dudswell pond at Bald Peak, twenty-four miles east of Sherbrooke. It is a continuation of the Capelton hills and has a like origin and a similar geologic structure. The northern side presents a serrated ridge as seen from the vicinity of Stoke Centre and is, throughout, the highest part of the entire elevation. The southern face is less elevated, but yet it is generally a quite abrupt feature of the landscape. The intervening part of the mountain, while having a general southward slope, is yet very poorly drained, and in this wet season much of it was an impassible swamp. The rock exposures in it are very few.

Iron pyrites.

The northern ridge of the mountain shows little evidence of the presence of copper. In the sixteenth lot of the eighth range of Stoke, on the farm of Joseph Tremblay, iron pyrites occurs in considerable amount in an elliptical mass some two feet thick of quartz and calcite and also in the slaty country rock.

This locality and a somewhat similar one on lot 15, range X, of Stoke are in the Cambrian measures a quarter of a mile north of the Pre-Cambrian. They are the only occurrences of metallic constituents in notable amount that I saw on the north side of the mountain, with the exception of a small occurrence on lot 21, range V. of Ascot Corner. Mr. C. W. Maynard informs me, however, that some occurrences of pyrites are to be seen on the neighbouring hills north-west of the Wattopekah river.

The central portion of the Stoke mountain is so far drift-covered and so heavily forested that little information can be obtained regarding the nature of the underlying rocks. A few specimens were taken and will be studied in detail. But several large brooks which rise in this depression have cut deep gorge-like channels through the southern edge of the mountain and so afford excellent rock exposures there. That part of the mountain is thus shown to be a continuous mass of sheared volcanics identical in character with those of the Capelton hills. Like them also these rocks contain rusty zones running parallel to the lamination of the rock, which are due to the oxidation of pyrites which the rock contained when fresh. These rusty zones, which are important surface indications of ore deposits, are especially frequent on the Mills, Big Hollow, Harrison, Kingsley, Jenkerson, Rowe and Willard or Hall's brooks. They were also observed in several places on lot 27, of the VIIIth range, of Ascot Corner.

Occurrence of gold.

The occurrence of gold too seems to indicate the presence of copper throughout this locality, as in other parts of the belt. The relation of these minerals in the Capelton hills points clearly to their genetic connection. This is well shown at the Eustis mine. There the volcanic rocks of the copper-bearing belt rise with a steep slope on the southern side and are overlain near the crest by sedimentary slates. In a small brook which runs near the mine, I am told by Mr. Blue, the manager, alluvial gold occurs in small quantities and assays of the quartz veins which cross the brook also yield gold as far up the brook as the volcanic rock is exposed. Beyond this no gold has been found either in the gravels or in the bed rock.

Alluvial gold has been found probably in all the brooks on the south side of Stoke mountain and especially in Westbury and Dudswell, and its source has been shown by Dr. Chalmers to be undoubtedly in the Pre-Cambrian rocks. In fact visible gold occurs in the rock in a few places. These facts have generally diverted the prospectors' attention from the search for copper which the geological conditions indicate may yet be found to be the more important mineral resource of this district.

Lake Weedon to Lake Aylmer.

From the vicinity of Lake Weedon to Lake Aylmer the Pre-Cambrian, which is covered by Cambro-silurian and Silurian sediments from Dudswell pond eastward, again appears. Time did not permit of a detailed examination of this area which its importance seems to warrant, but a brief visit to some points west of Lake Weedon show the area to be a promising one. As far as seen it consists of an igneous rock of rather plutonic character of crystallization and somewhat resembles part of the northern ridge of Stoke mountain. It differs from that, however, in containing copper apparently in important quantities. On lots seventeen and eighteen of the third range of Weedon, iron and copper pyrites occur in veins, masses and small grains in the country rock. Outcrops of this character have been found at various places on these two lots. Other occurrences of copper are reported from different parts of this district, so that it seems worthy of detailed examination.

On the South Ham road, four miles east of Marbleton, Mr. William Mackie showed me a block of pyrites, said to have been found near a ridge which forms a connecting link topographically between Stoke mountain and the Weedon hills. This ridge was crossed in several places farther westward but was there found to be composed wholly of later sedimentary rocks. Yet, being wooded in the part of the ridge mentioned, and hence not satisfactorily examined, an outcrop of the copper-bearing rocks may yet be found in this vicinity.

Rocks of Lake Megantic area.

The third area of rocks of Pre-Cambrian age, which has been mentioned, occurs along the boundary line between the province of Quebec and the states of New Hampshire and Maine. It lies chiefly in the townships of Emberton, Chesham, Woburn, Clinton, Louise and Ditchfield. Its similarity in age to the Sutton and Ascot copper-bearing areas, together with the reported occurrence of cupriferous blocks in the vicinity, made it desirable to visit the locality. Accordingly the exposures along the Canadian Pacific Railway were carefully examined in Ditchfield township between Boundary and Trudel sidings; then the road from Woburn landing at the head of Lake Megantic to Channay and thence to the Arnold river; after which the road from Channay to Chesham or Notre Dame des Bois was examined. The rocks seen in Ditchfield were found to be gray volcanics essentially similar in character to those already described from Sutton and Ascot. In a cutting of twenty rods in length near the 189th mile post from Montreal the rock is everywhere rusted from the

Copper.

oxidation of pyrites. In the central part copper and iron pyrites comprise probably ten to twenty per cent of the rock through a belt of

ten yards in width. As it crosses the line of the railway at an oblique angle the width of the belt is, however, somewhat less than thus appears.

Between Woburn landing at the south-west extremity of Lake Megantic and the village of Channay, the principal rock exposure is an abrupt hill some five hundred feet high in lots 10, 11, 12 and 13 in ranges I and II of Clinton. This is locally known from its peculiar profile as the 'Scotch Cap.' Its igneous origin is denoted by the colouring on the Geological Survey map of 1886. Lithologically it is found to be identical with the basic volcanics of Sutton and Ascot. Chlorite and epidote are prominent constituents of the rock. No copper was seen in it.

I was informed by the Rev. Père Huard, curé of Channay, that bornite had been found on the bank of the Arnold river two and a half miles from Channay, and that preparations were being made to develop the property. As it was said that the exposure could only be seen at low water, and the water in the river being very high at the time of my visit, I did not go to the locality.

Along the road between Channay and Chesham, or Notre Dame de Bois, rock exposures are numerous and are wholly of the basic volcanic class. Rusty patches similar to those already mentioned were observed in a few places.

Extent of copper-bearing belt. The similarity of these rocks to those of the known copper-bearing belts, the known occurrence of copper in Ditchfield, and the fact that chloritic and epidotic rocks have been reported by many observers in the highlands of Gaspé, point strongly to the possible great extent of this volcanic belt. It seems possible that the watershed which determines the Maine boundary line may, when the country becomes accessible for detailed examination, yet be found to form a more or less continuous ridge of copper-bearing volcanics, perhaps to be ultimately connected with the cupriferous Pre-Cambrian of New Brunswick.

Other areas.—Another occurrence of copper, which is not related in position or geologic relation to those already described, is found on the west side of Lake Memphremagog, principally in the townships of Potton and Bolton. **The Smith mine, Knowlton Landing.** The largest of these, the property of Mr. G. E. Smith, is about two miles from Knowlton Landing but I was not able in the time available to ascertain the full extent of this occurrence. It has been developed by sinking a shaft some eighty feet in depth while a horizontal tunnel, one hundred feet in length, cross-cutting the ore body reaches the shaft fifty feet from the surface. The course of the

cross-cut is towards Sugarloaf mountain on the west side of which the mine is situated, and the ore body seems to be a phase of the zone of contact of an intrusive mass of the mountain with the surrounding sedimentary rocks. A curious repetition of these conditions in miniature is found three-quarters of a mile north of G. E. Smith's mine on the farm of John Burbank. Here a small intrusion of plutonic rock (granite or diorite) cuts the same sediments which border on the west of Sugarloaf and produce in a contact zone two feet in width a few inches of similar ore.

Character of ore.

The ore is a pyrrhotite said to carry a small percentage of copper. It oxidizes very readily giving a strong odor of sulphur in the shaft. The amount of sulphur, of which it is reported to carry 35 per cent, which is carried out in solution by water is surprisingly large. Drift material, fallen branches and leaves of trees are cemented together by the iron thus leached out. Several inches of this recent conglomerate are said to have been deposited since the uncovering of the ore body ten or twelve years ago. I was much assisted in the brief examination made of this locality by Mr. O. Rexford, B.Sc., of Knowlton Landing.

Similar ores occur at several places in Potton and Bolton, but no others have yet been found to be of so great extent. The occurrence of intrusive rocks is so frequent in this district, however, that a repetition of the conditions of the Smith mine might be looked for with every prospect of success amongst them. This is in fact one of the most important localities for detailed prospecting in the eastern townships.

General conditions of mining.

General conditions.—The conditions of transportation, mining and treatment of ores have greatly changed since the early 'sixties,' when active work was general in the mineral-bearing districts of the eastern townships. The decline in the price of copper has been followed, though at some distance of time, by changes of an opposite tendency. The clearing and general opening up of the country has been accompanied by the establishment of abundant railway facilities, which with the exception of the Grand Trunk Railway date subsequently to the closing of most of the mines. The Intercolonial and the Drummondville branch of the Canadian Pacific Railway run longitudinally throughout the length of the Acton belt. The latter line also runs within the Sutton belt from Foster to the Vermont boundary, passing in the immediate vicinity of the principal mines of that area, which were formerly from thirty to fifty miles from a railway. The Canadian Pacific Railway towards Sherbrooke now passes through the township

Railway facilities.

of Bolton and further eastward crosses the boundary line in the volcanic area of Ditchfield. The Boston and Maine Railway runs parallel to the Capelton hills at their foot, while the Quebec Central skirts the Stoke mountain on its southern side throughout its length, crosses the Weedon and Lake Aylmer district, and follows the south-eastern side of the Sutton belt from the vicinity of the Harvey Hill mines to the Chaudiere river. Thus these mines, for instance, which were formerly twenty-five miles from a railway are now brought within seven.

The Orford Mountain Railway also opens an important part of the townships of Stukely and Ely in the same belt.

To these, advantages and advancement in means and methods of mining and smelting must be added. At present the only smelting works in the district are those of the G. H. Nicholls Chemical Co. at Capelton. Here custom work is occasionally done, but mill tests seem to be too rarely made in the development of smaller properties, the tendency being to rely too much upon assays of hand specimens, the method of selection of which it is always difficult to determine. A movement is also on foot to establish a custom smelter at Sherbrooke. Under all these changed conditions, therefore, the production of copper in the eastern townships becomes a new economic question, and one very different from that of thirty-five years ago when most of these mines were closed. Smelting works.

APPENDIX.

ANALYSES OF ROCKS FROM BROME MOUNTAIN.

(By Mr. M. F. Connor.)

Rock analyses.

	No. 4561	No. 4575	No. 4582
$Si\,O_2$	44·00	55·68	61·77
$Al_2\,O_3$	27·73	20·39	18·05
$Fi_2\,O_3$	2·36	2·10	1·79
$Fi\,O$	3·90	1·95	1·75
$Mg\,O$	2·30	0·80	0·89
$Ca\,O$	13·94	1·92	1·54
$Na_2\,O$	2·35	9·18	6·83
$K_2\,O$	0·45	5·34	5·21
$H_2\,O$	0·80	1·50	1·10
$Ti\,O_2$	1·90	0·60	0·74
$P_2\,O_5$	0·20	0·06	0·15
$Mn\,O$	0·08	0·31	0·15
	100·41	99·83	99·97

No. 4582 is a light gray or fawn coloured rock with a generally granitic structure and coarse texture. Feldspar and specks of dark mica and hornblende can be discerned in the hand specimen.

By the aid of the microscope microperthite is seen to be the greatly predominating constituent of the rock. In addition to biotite and a green hornblende, which are present in very subordinate amounts, sphene is also present with needles of apatite and an occasional grain of iron ore.

The rock belongs to about the laurokite class described by Brôgger in Southern Norway.

It was formed by the second great intrusion of Brome Mountain laccolite.

No. 4575. This is a greenish-gray ingrained rock containing well marked phenocrysts of orthoclase feldspar.

The groundmass of this rock consists either of an unindividualized base or of patches of granular feldspar and ferro-magnesian material. It has yet to be studied in detail.

It forms the third intrusion of Brome mountain.

No. 4561. This is a massive rock, gray in colour, and weathering to a dull brown. The structure is granitoid and the texture medium.

Feldspar and small amounts of dark minerals, chiefly hornblende, mica and iron, can be distinguished in it by the unaided eye.

In the thin section basic plagioclase is found to make up as much as 90% of the rock. The remaining constituents are pyroxene, olivine and biotite, with accessory magnetite and apatite.

Hornblende enters into the composition of many parts of the rock in amounts quite equal to pyroxene, but in others seems to be entirely absent.

The rock passes in places into essexite and theralite, to which rocks it is somewhat closely allied. Its varietal classification will be determined when the mineral constituents have received a little more detailed study in connection with the calculation of its chemical composition.

It is the earliest of the three intrusive masses which form the igneous part of Brome mountain.

Palæontology and Chronological Geology.

H. M. Ami.

(A.) Manitoulin Island District.

During the past year much time has been spent in determining the collections of organic remains from various localities in the Manitoulin Island region of Lake Huron, in the province of Ontario. Faunal lists were prepared and the geological horizon which these predicated were given.

The principal localities from which these collections were obtained by the various officers of the Geological Survey, from 1847-1898, and the geological horizons they indicate, so far as the collections and mode of preservation of the specimens permitted, are here given. The collections count no less than 184, but only the more important ones are now recorded for the sake of reference:—

THE CHAZY FORMATION.

1. In his list of the fossils from the island furthest south of the group off Point Pallideau, Lake Huron, E. Billings notes that the occurrence of *Modiolopsis parviuscula*, *Vanuxemia inconstans*, *Pleurotomaria staminea* and *Lingula Huronensis*, species known to occur in the Chazy of different portions of Ontario, notably in the Montreal-Ottawa-Champlain Basin. No evidence of the presence of the Chazy was obtained by me from the numerous collections examined, but the foregoing determinations made by Billings are undoubtedly accurate and the presence of the Chazy formation in the region in question must accordingly be recorded from the 'island furthest south of the group off Point Pallideau.'

BLACK RIVER AND TRENTON FORMATIONS.

2. Saint Joseph Island, Gravel Point, Lake Huron, T. C. Weston, 1882.

3. Goat Island, south of Lacloche Island, Lake Huron, Robert Bell, 1892.

4. Great Cloche Island, near Little Current, Lake Huron, Robert Bell, 1892.

5. Island opposite camp near junction, west side Lacloche Island, Murray, 1847.

6. West side of Lacloche Island, Lake Huron, Alex. Murray, 1847.

7. Islands between Lacloche Island and Manitoulin Island, R. Bell, 1859.

8. Fossils from the lower bed of the escarpment west of the limekiln near Hilton Village, St. Joseph Island, Lake Huron, Alex. Murray, August 15, 1860.

9. Fossils from the south-western Pallideau Island, opposite the Bruce Mines location, A. Murray, 14th September, 1867.

10. Island west of Grant Island.

UTICA FORMATION.

11. Along the shores of Shequenandod Bay and Islands, A. Murray, 1847.

12. Islands north of Maple Cape, Manitoulin Island, Lake Huron (collector and date not given on the specimens, but probably A. Murray, 1847). Zone of *Triarthrus Canadensis*, Smith.

13. Little Current, Manitoulin Island, Robert Bell, 1892.

LORRAINE OR RICHMOND FORMATIONS.

14. *Summit of the Ordovician System—precise formation not ascertained.* Manitoulin Gulf, Head transition beds.

15. Between Cape Crocker and Montrésor (collector and date not given.)

16. Manitouwaning Bay, Lake Huron, in the upper part of the "Hudson River Group," R. Bell.

17. Ledge, top of shale, East Gore Bay, R. Bell, 1866.

18. Wekwemikong shore, Manitoulin Island, Lake Huron, R. Bell, 1892.

19. East side of Gore Bay, top of cliff, R. Bell, 1867. A commingling of Richmond and Lorraine formation species occurs in the collection. Both formations probably occur in the escarpment.

20. East side of Gore Bay, ledge of top shale, Manitoulin Island. Lake Huron, R. Bell, 1867.

LORRAINE FORMATION.

31. Griffiths Island, near light house, Alex. Murray, 1861.

22. Wekwemikong, Manitoulin Island, Lake Huron (collector and date not given but probably Alex. Murray).

RICHMOND FORMATION.

23. Establishment at Manitouwaning, Manitoulin Island, (collector and date not given).

24. Fossils from a point about 20 ft. high at N. E. point of Drummond Island, Lake Huron. Alex. Murray, Aug. 14, 1861.

25. Cape Smyth, Lake Huron, Robert Bell, 1859.

26. Cape Rich, Lake Huron, Robert Bell, 1859.

27. East side Manitouwaning Bay, near head, Robert Bell, 1865.

28. West side, Cape Robert, Manitoulin Island, Robert Bell, 1865.

28. Ka-ga-wong clearing, Manitoulin Island, Robert Bell, 1865. East side of West Bay, one mile from village, Manitoulin Island, Robert Bell.

29. East side of Gore Bay, Manitoulin Island, Robert Bell, 1867.

30. East side of Gore Bay, R. Bell, 1867, (Middle Terrace).

31. South side of Lacloche Island (collector and date not given).

32. Drummond Island, North Point.

CLINTON AND NIAGARA FORMATIONS.

33. Cliff over Cape Wingfield, about 138 feet over the lake, Manitoulin Island region, Lake Huron, A. Murray, July 18, 1861.

34. McLeod Harbour, two miles north of harbour, R. Bell, 1859.

35. Providence Bay, Manitoulin Island, Lake Huron, R. Bell, 1865. North-west corner of Ka-zoo-wong Lake, R. Bell, 1868.

36. South-east extremity, Elizabeth Bay, Robert Bell, 1865.

37. North-east extremity of South Bay, Manitoulin Island, Robert Bell, 1865.

38. North-west extremity, Manitoulin Island, R. Bell, 1865.

39. Ninety fossils from one mile S. S. East Head Gore Bay, Manitoulin Island, Robert Bell, 1866.

40. Top of cliff, East Gore Bay, R. Bell, 1866.

41. Wekwemikong Hill, Manitoulin Island, Robert Bell, Sept., 1892.

42. Lot 28, Concession VI., Township of Allan, Manitoulin Island, Lake Huron, Robert Bell, 1892.

43. South side of Manitoulin Island opposite the middle of Stone Lake, same as Lot 28, Con. VI., Township of Allan, Robert Bell, 1892.

44. Between South Baymouth and Blue Jay Creek, half way in the central portion of the area supposed to be Guelph in age, Grand Manitoulin Island, Ami, 1898.

45. Michael's Bay, west side, Manitoulin Island, south shore, Ami, 1898.

46. One and a quarter mile from where the post road crosses Blue Jay Creek, between Michael Bay and South Baymouth, Township of Tehkummah, Grand Manitoulin Island, Ami, 1898.

47. Between Manitou and Blue Jay Creek, Township of Tehkummah, Grand Manitoulin Island, Ami, 1898.

48. Ledges about two miles north of South Baymouth on the road to Michael Bay, Grand Manitoulin Island, Ami, 1898.

49. Old coral reef, six miles north of South Baymouth, west side of bay, Township of Tehkummah, Grand Manitoulin Island, Ami, 1898.

50. Fossils from Cape Chin, Lake Huron, Alex. Murray, 1848.

51. Entrance to South Bay, Manitoulin Island, Robert Bell, 1865.

52. Barrier Island, Lake Huron, fossils from loose slabs of limestone. Pentamerus beds, (collector and date not given).

53. Cockburn Island, Lake Huron region.

54. Drummond Island, south-west end, A. Murray, 47, 1826.

55. Fairview Cove, Drummond Island, Lake Huron, Robert Bell, 1866. South side and west end of Drummond Lake, Lake Huron, Geol. Survey collection, determined by the late Mr. E. Billings.

56. East side of the village in the bight of West Bay, Manitoulin Island, R. Bell and H. G. Vennor.

To this horizon are assigned the gray shales, coral-bearing rocks, of the southern portion of the Island, and cream-coloured and gray fossiliferous limestones of the south shore of the Grand Manitoulin Island, near South Bay Mouth, Lake Huron, besides the gray limestones of Flower pots, Perseverance and Cove Islands.

57. West side of Thomas Bay, south shore of Manitoulin Island, Lake Huron, H. M. Ami and W. J. Stewart. July 29, 1898. (Zone of *Astrocerium venustum*, Hall.)

58. Irving Point, east side of South Bay Mouth, Grand Manitoulin Island, Lake Huron, H. M. Ami and W. J. Stewart, July 29, 1898.

59. Flowerpots Island, near the lighthouse, Lake Huron, H. M. Ami, 1898.

60. Perseverance Island, Lake Huron, H. M. Ami, 1898.

61. Cove Island, near lighthouse, H. M. Ami, 1889.

Besides the above there are a large number of geological collections to which a precise geological horizon cannot be assigned without doubt, inasmuch as the evidence afforded by the materials examined was insufficient. Of these collections there are those which indicate the presence of summit beds of the Ordovician system, but which on account of the character of the material, cannot serve to determine whether the Lorraine or Richmond or both occurs. It is greatly to be desired that further material be obtained so as to complete the work.

Fossils from the island furthest south of the group off Point Pallideau, Lake Huron, as determined by the late Mr. Billings, indicate a horizon which is decidedly older than the Birdseye and Black-river formation and point to the existence at this locality of the Chazy fauna and formation. Additional material from the locality is much desired.

As regards the presence of the Guelph formation, the writer has not as yet recorded any occurrences of typical species of fossils of this formation in the collections examined from the Grand Manitoulin region.

Accompanying my report now in the hands of Dr. R. Bell on the determinations of the organic remains from various localities, in the Geological Survey Museum will be found a general review of the palæontological evidence at hand in the writings of the following geologists and palæontologists: J. J. Bigsby and Charles Stokes in 1824; of Charles Stokes again in 1849; Elkanah Billings in 1862, 1863 and 1866; H. Alleyne Nicholson in 1875; George Jennings Hinde in 1879; Arthur H. Foord in 1889; H. M. Ami in 1892; J. F. Whiteaves in 1896; H. M. Ami in 1899; and L. M. Lambe in 1900 and 1901.

It is extremely desirable that further collections be obtained from the Ordovician and Silurian succession of the Manitoulin Island district of Lake Huron, inasmuch as the sedimentation of that area is not only quite distinct from that of the Niagara and Toronto districts of the Ontario basin, but bears strong resemblance to the succession known and recorded in Indiana, Ohio and Kentucky to the south, as well as to that of the Island of Anticosti, in the valley of the St. Lawrence east.

Especially is this resemblance a striking one as regards the calcareous sediments of the Richmond formation, whose presence in the Grand Manitoulin island had not been hitherto detected.

B. Ontario and Quebec.

Faunal lists, together with the horizon they indicate, were prepared by me during the year 1902, from various localities in Central and Eastern Ontario and in a portion of the Province of Quebec along the Ottawa Valley.

From Belleville, Havelock, Douro, Dummer, Vensikle and Oak Lake settlements and other localities in Central Ontario, as well as from twenty-five localities in the Kingston district, such lists were prepared for Dr. A. E. Barlow's and Dr. R. W. Ells's reports respectively.

Work on Pembroke sheet.

Faunal lists were also prepared by me during the year from numerous collections and localities in connection with the Pembroke sheet or geological map of the Ottawa Valley about Pembroke in charge of Dr. R. W. Ells. The geological horizon indicated by the fossil remains entombed in the strata from which they were derived has also been added. The separation of the limestones of the Chazy, Birdseye and Black River, and of the Trenton formations, which occupy distinct positions in the succession of Ordovician strata of the Ottawa Valley was carefully effected and the value of the palæontological determinations and evidence thus obtained materially assisted in the mapping out of the various strata and formations in the district. To these were added lists previously determined by J. W. Salter, and E. Billings from various localities in the same district and published in scattered reports.

Collections examined.

Some of the more important collections examined are from the following localities :—Paquette's Rapids, Fourth Chute of the Bonnechère, Clear Lake, Allumette Island, Westmeath, Fitzroy, Packenham, McNab, Stafford, Torbolton, Aylmer and Marlborough.

These faunal lists, together with the horizons they indicate, are intended to accompany Dr. Ells's report, in the form of an 'Appendix.'

Work on Kingston sheet.

Similar lists were prepared by me from the determinations made by myself in conjunction with Dr. R. W. Ells's work in the counties of Prince Edward, Lennox, Hastings, Addington, and also in the Kingston district during 1901. They include the following localities :—Kingston, Portsmouth, Rideau Station, Kingston Mills (Piloceras beds of Billings the zone of *Nanno aulema* Clarke), Kingston Quarries, Collins Bay Quarries, Westbrook Hill, Battersea (Vanluvin's mills of 1863 Report), Wolfe Island Quarries, Simcoe Island, Horse-shoe Island, Gildersleeve's Quarry, Picton, West Point near Sandbanks, Barriefield Hill, Deadman's Cove, Cherry Valley, Veesey Point, Ox

Point Quarries, opposite Mississaga Point and Belleville. Barytes Mine at Woodruff's, lots 16 and 17, Con. IV, also south half of the lot 16, Con. V and lot 15, Con. V, in the Township of Kingston, County of Frontenac.

Notes on collection of fossils, &c., made in 1886 by Mr. Eugene Coste and myself in Central Ontario were prepared by me in connection with Dr. A. E. Barlow's and Dr. Adams's work on the geology of that part of the province.

The species of fossil remains recognized in these collections were listed, the horizons which these predicated were also given, together with brief descriptions of the leading characters of the strata from which the fossils were derived. They include collections from a number of small outliers at Oak Lake, Round Lake, Breckenridge, Shenick and Vansikle. These notes were duly handed to Dr. A. E. Barlow and form a preliminary note on the fossils found in the Palæozoic formations of Central Ontario, along the line of contact between them and the Archæan.

C. Nova Scotia.

Considerable progress was made in connection with the descriptions and classification of the faunas in the Silurian system as developed in Nova Scotia, with special reference to the Arisaig section, Antigonish Co. In this I was assisted by Mr. C. Frank King and a few drawings were made by Mr. O. E. Prudhomme. Inasmuch as it is not only important but necessary to have proper illustrations made of the various species represented in the departmental collections, the writer desires to emphasize the urgency of the needs of illustrating the various types which form a series quite unique for this continent both as regards their assemblage and characteristics. **Work on Silurian faunas.**

D. Division of Ethnology and Archæology.

Some time was also spent in entering and cataloguing the various additions to the ethnological collection of the museum made during the year. These collections are obtained by the members of the field staff during their explorations or from the general public interested in the discovery and preservation of archæological records in Canada. **Accessions to museum.**

A list of the accessions made to the ethuological collections during the past year appears in another portion of this Summary Report.

E. Important accession to the Palæontological collections.

An important collection of fossils of Cambrian age from Cape Breton was received in February, through Dr. G. F. Matthew of St. John, **Cape Breton faunas.**

New Brunswick, which serves to illustrate the various forms characterizing the geological formations of that portion of Nova Scotia. There is a striking resemblance between these faunas of Cape Breton and corresponding faunas in Wales. The following localities are represented :—Trout Brook, Mira River, Escasonie, McAdams shore, Barachois Station, I.C.R. cutting, Long Island, McInnis Brook, Gregwa Brook, Dugald Brook, McLeod Brook, Boisdale.

These form a valuable addition to our already extensive collection of Cambrian fossils. Owing to lack of space, however, it will be impossible to exhibit them until the already over-congested condition of the museum is relieved by the erection of a new building.

Mount Stephen fossils.

To Dr. G. F. Matthew the department is further indebted for determinations of species from the Cambrian of Mount Stephen, collected by myself in 1891.

Accessions to the palæontological collections of the department were recorded and many of the species represented determined in so far as the mode of preservation allowed.

Acknowledgement.

The department is again under obligation to Prof. D. P. Penhallow of McGill University, Montreal, for identifications of fossil plants sent to him for determination. Several collections which were in the hands of Sir William Dawson, in Montreal, at the time of his death, have been determined by Prof. Penhallow and forwarded to the department.

F. Bibliography of Canadian Geology.

Work on catalogue of 'Geological writings of Canada.

A number of additions to the 'Catalogue of writings on the Geology and Palæontology of Canada' in course of preparation and completion were made by me during the year, together with the references to the current literature on the same subjects for the year 1901. Copies of the 'Bibliography of Canadian Geology and Palæontology for 1901' were prepared during the year, and a number of abstracts of the leading works on the palæontology of Canada were prepared for Dr. K. Keilhack's 'Geologisches Centralblatt' in Berlin, Germany, for the Transactions of the Royal Society of Canada, and also for the International Catalogue of Scientific Literature in connection with the Royal Society of England, for which latter, Prof. J. G. Adami of McGill University, is the recorder. The whole catalogue to date counts upwards of five thousand references to Canadian publications on geology and palæontology.

G. Comparative studies while in Great Britain.

When in Europe during the months of June and July, comparative studies of the faunas of the Silurian of Great Britain were carried on by me in the British Museum, Natural History Department, and in the Museum of Practical Geology in connection with the Geological Survey of Great Britain, as well as in the Museums of Cambridge and Birmingham Universities, also at Ludlow in Herefordshire. Studies in England.

At the last-named place, collections of fossils were made illustrating the faunas of the Lower and Upper Ludlow, the Tilestone and Old Red Sandstone. This region constitutes the classic ground of Sir Roderick Murchison's 'Siluria,' and the materials obtained will be of special value in defining the limits of the various geological horizons occurring in Eastern Canada and comparing their faunas.

While in London, some time was spent with Dr. Henry Woodward, of the British Museum, in examining a collection of trilobites and other fossils from the Cambrian of Mount Stephen, in the Canadian Rocky mountains, recently made by Edward Whymper, Esq. Work on Mount Stephen trilobites.

H. Bibliography for 1902.

During the year 1902, a number of papers bearing upon the geology and palaeontology of Canada, including some of the official reports published by this department, were prepared by me and published either in full or in abstract, as follows :— Bibliography

Appendix. Preliminary lists of the organic remains occurring in the various geological formations comprised in the map of the Ottawa district, including formations in the provinces of Ontario and Quebec, along the Ottawa, pp. 49 G—77 G. Annual report, part G, Vol. XII. (Appendix to report by R. W. Ells) No. 741.

On *Belinurus Kiltorkensis*, Baily. American Geologist, Vol. 29, No. 3, p. 188. Minneapolis, March, 1902.

'The Great St. Lawrence-Champlain-Appalachian Fault of America and some of the geological problems connected with it.' Abstracts of Proc. Geological Society, London, No. 764. Series 1901-02, pp. 129-130, and 131 (discussion) London, Eng., June, 1902.

'Bibliography of Dr. George M. Dawson'. Canadian Record of Science, Vol. VIII, No. 8, pp. 503-516, Montreal, July, 1902. Separate issue, December 17, 1902.

'The Meso-Carboniferous age of the Union and Riversdale formations of Nova Scotia (Read before the Geological Society of America, Jan. 2, 1902) abstract. Science, Vol. XV, No. 368, p. 90, New York City, Jan. 17, 1902.

Notes on the Albany meeting of the Geological Society of America, held December, 1900. Canadian Record of Science, Vol. VIII, No. 7, pp. 471-477. Jan. 1902.

Annual Report of the Geological Section of the Ottawa Field-Naturalists' Club, for the year 1901-02. Addressed to the Council of the O. F. N. C. (Read Jan. 14, 1902) Ottawa Naturalist, Vol. XV, No. II, pp. 254-262, Feb. 5, 1902.

'The Union and Riversdale Formation in Nova Scotia.' (Discussion and correspondence.) Science N.S. Vol. XV, No. 375, p. 392. March, 7, 1902. New York City, N.Y., U.S.A.

The Cambrian age of the *Dictyonema* slates of Nova Scotia. Geological Magazine, Vol. 9. May, 1902, pp. 218-219, London, Eng.

Field-notes on the geology of the country about Chelsea, Que. Ottawa Field-Naturalists' Excursion, Chelsea, Sept. 6, 1902. Ottawa Naturalist, Vol. XVI, No. 7, pp. 149-151, October 6, 1902.

The Ordovician Succession in Eastern Ontario (Read before the Geological Society, America, Rochester, Dec. 31, 1901. Science, Vol. XV, No. 368. New York, Jan. 17, 1902, p. 82. abstract.) (With note on discussion by Bailey Willis, W. M. Davis and Hon. C. D. Walcott).

(*I.*) NOTES ON DRILLINGS OBTAINED IN SIX DIAMOND-DRILL BORE-HOLES IN THE BED OF THE ST. LAWRENCE RIVER AT VICTORIA COVE, SILLERY, EIGHT MILES ABOVE QUEBEC CITY, QUEBEC.

Through the kindness and courtesy of Mr. E. A. Hoare, engineer for the Quebec Bridge Co., Quebec, I had an opportunity afforded me of examining the drillings extracted from the six diamond-drill bore-holes which serve to indicate the character of the rock formations and materials occurring in the immediate vicinity of the abutments, anchor piers and main piers of the Quebec bridge now in the process of completion. The logs of the different borings were carefully preserved in boxes, and the following notes have been prepared by me, together with the sketch sections or illustrations accompanying them.

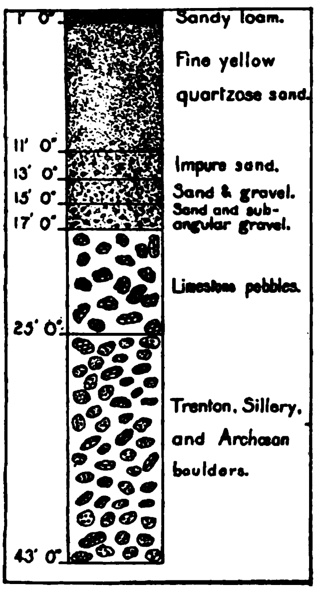
DESCRIPTIONS OF DRILLINGS.

North Side of the St. Lawrence River.

No. 1 Bore-hole. 43 feet. Anchor Pier, on centre line, 400 feet north of No. 3 bore-hole. Shore above water level.

Bore-hole No. 1.

After penetrating the surface soil which consists of a sandy loam one foot in thickness in which grains of clear quartz abound, the drill traversed ten feet of fine yellow quartzose sand below which occurred two feet or more of rather impure sand, two feet more of sand and gravel underlaid by two additional feet of sand and fine subangular gravel. Eight feet were then traversed, in which limestone pebbles predominate, thus reaching a depth of twenty-five feet. Between twenty-five and forty-three feet depth, boulders of Trenton limestone associated with boulders of Archæan crystalline rocks and pebbles of sandstones belonging to the Sillery grit formation occur. This bore-hole was not continued deeper.



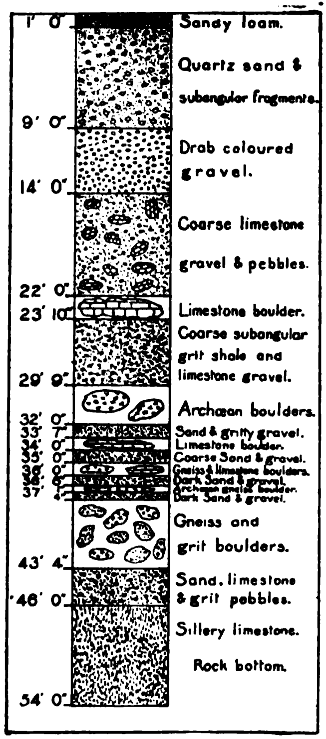
Bore-hole No. 1 North Side.

No. II Bore-hole. Fifty feet east of the centre line.

Bore-hole No. 2.

Drillings consist first of about one foot of sandy loam, followed downward by eight feet of quartzose sand rather coarser than the materials examined in bore-hole No. 1, together with a number of small subangular fragments of various kinds of rock and shale. Below this the drillings consist of five feet of a fine, well mixed, drab-coloured gravel underlaid by eight feet of coarse limestone gravel not unlike that met at the twenty-five feet depth in bore-hole No. 1. The next twenty-two inches were marked by the presence of a boulder of fossiliferous limestone underlaid by five feet and eleven inches of coarse and well mixed subangular pebbles of Sillery grit, Palæozoic limestone, shale, etc. In the next two feet three inches, a boulder of a dark crystalline Archæan basic rock occurs, probably dyke material, with garnet, etc., underlaid by one foot seven inches of coarse brownish gray quartzose sand associated with grains of felspar and grits. A

lime-stone boulder was met in the next five inches at a depth of thirty-four feet below which sand similar to that overlying the boulders of limestone just described above, occu rred to a depth of one foot, underlaid by two boulders, one, consisting of sedimentary or Palæozoic limestones, the other, an Archæan gneiss boulder. Eight inches of a dark-coloured, quartzose sand holding fragments of gneiss, the grains of both being subangular, are underlaid by a boulder of Archæan gneiss five inches in thickness, below which three inches of dark coloured sand occurred similar to that above the last mentioned boulder. Six feet were then traversed marked by the presence of boulders, of gray gneisses of Archæan age, and others of Sillery grit, underlaid by some eight inches of dark sand similar to that just described, in which were imbedded pebbles of Sillery grit, and limestone of Trenton or Black River age. The next ten feet, reaching a depth of fifty-four feet, were drilled in solid rock of typical Sillery grit, similar to that which occurs in the face of the escarpment on the north side of the river at Victoria Cove, Sillery.

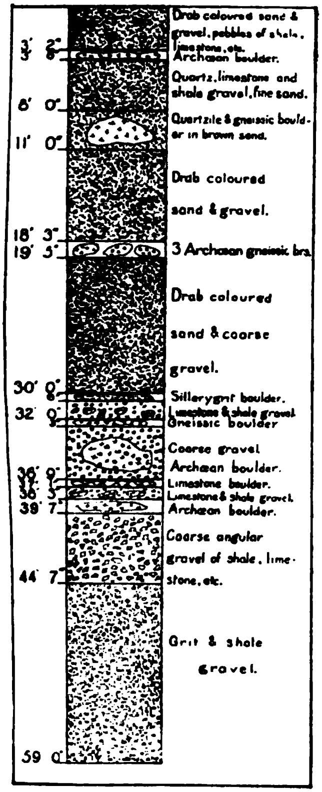


Bore-hole No. 2, North Side.

Bore-hole No. 3.

No. III Bore-hole, 480 feet from base line, on the centre line ; measurements taken from the river bed. Bed of River St. Lawrence.

Drillings at this point consist of three feet two inches of drab coloured sand and gravel in which quartz grains predominate and fragments of felspar, limestone, arenaceous shale (resembling shales of the Lorraine formation) associated with pebbles of Archæan and Trenton (Ordovician) age, are underlaid by a boulder of Archæan rock eight inches in thickness, below which are four feet four inches of angular fragments of quartz, limestones, shales, rather free from sand and well washed and preserved. The next three feet consisted of a white quartzite and biotite (gneiss or coarsely crystalline pegmatite) boulder imbedded in a rusty, chocolate coloured sand followed downwards by seven feet three inches of drab-coloured mixed fine and coarse



Bore-hole No. 3, North Side.

gravel below which were struck boulders of Archæan rocks consisting of light pinkish gray micaceous and hornblendic as well as biotite gneiss reaching to a depth of nineteen feet five inches. Similar gravel to that just described above the boulders of Archæan rocks then characterize the drillings for the next ten feet seven inches down to a depth of thirty feet where a six inch boulder of Sillery grit was traversed by the drill. The next eighteen inches were characterized by a mixed gravel of limestone and shale fragments whose average size was about one centimetre across, below which, according to the engineer, 'a piece of a boulder was picked up with the two-and-a-half inch pipe' measuring three inches across which consists of a pinkish Archæan gneiss. Four feet six inches of coarse, mixed, angular gravel with boulders of Archæan rock then follow under which occurred a boulder of fossiliferous limestone of typical Trenton age as may be inferred from the following lists of fossil remains recognized in its mass :— Fossils.

1. *Orthis (Dalmanella) testudinaria*, Dalman.
2. *Leptæna (Plectambonites) sericea*, Sowerby.
3. *Rhynchotrema inæquivalvis*, Castelnau.
4. *Pachydictya*, sp.
5. *Monticuliporoid*, indt.
6. *Trilobite* fragment, too imperfect for identification.

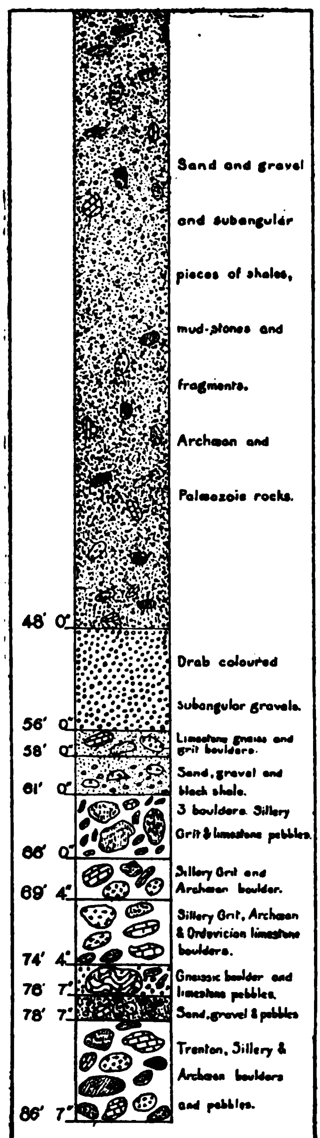
For one foot two inches below this Trenton boulder, similar gravel to that above the boulder occurred, followed downward by a boulder of Archæan crystalline rock to a depth of sixteen inches deeper, below which again, similar gravel was struck to a depth of forty-four feet seven inches. In the next fourteen feet five inches, the drillings gave a gravel of grit and shales. At the depth of fifty-four feet "the tube broke" and the bore-hole was abandoned.

South Side of the St. Lawrence River.

Bore-hole No. 4.

No. IV Bore-hole. Bed of river.

The drillings which were examined as representing the first forty-eight feet of the material obtained in this bore-hole consisted of small angular pieces of Archæan and Palæozoic rocks together with water-worn and well rounded and subangular pebbles of the same rock and gray shale or siliceous mudstone. These are followed downward for eight feet by drab-coloured and subangular gravel. Then two feet of somewhat angular gravel with rounded blocks of limestone and boulders of pinkish gneiss with Sillery grit were traversed. The next three feet showed the presence of a sand or gravel with drab and rather dark coloured black shale with which were associated pebbles of Archæan gneissoid rocks and fragments of limestone, shales, etc., at times very angular. Three boulders of Sillery grit or sandstone follow with lime stone pebbles in the next five feet of the drillings examined. These were underlaid by five feet four inches of similar rocks and pebbles, these in turn being underlaid by similar strata to a depth of seventy-six feet seven inches, where sand and gravel to a depth of two feet are then penetrated in which pebbles of Trenton limestone, of Archæan gneiss, of Sillery grit, black shale, etc., occur, followed downward by Trenton, Archæan and Sillery boulders to the bottom of the bore-hole at a depth of eighty-six feet seven inches where the drilling was abandoned.

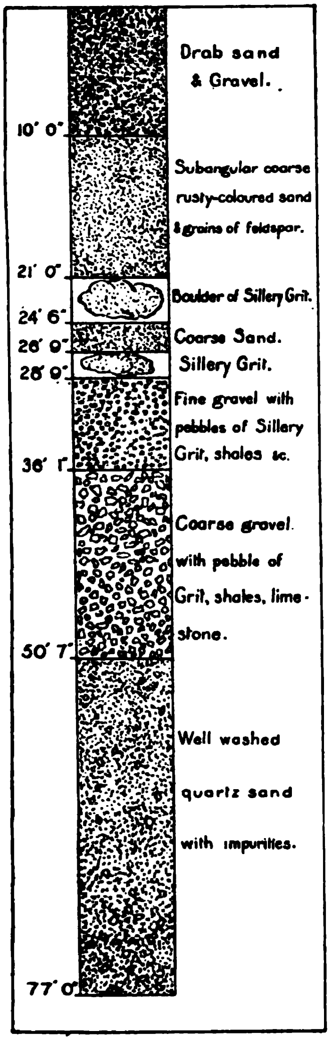


Bore-hole, No. 4. South Side.

No. V Bore-hole. Bed of river.

Drillings consist of drab coloured sand and gravel associated with Sillery grit materials to a depth of ten feet, followed by eleven feet of subangular and rather coarse sand with felspar fragments, in turn underlaid by a Sillery grit boulder three feet six inches in thickness below which, two feet three inches of a coarse sand, like that above, in which boulders of gneiss, limestone and grit occur.

Bore-hole No. 5.



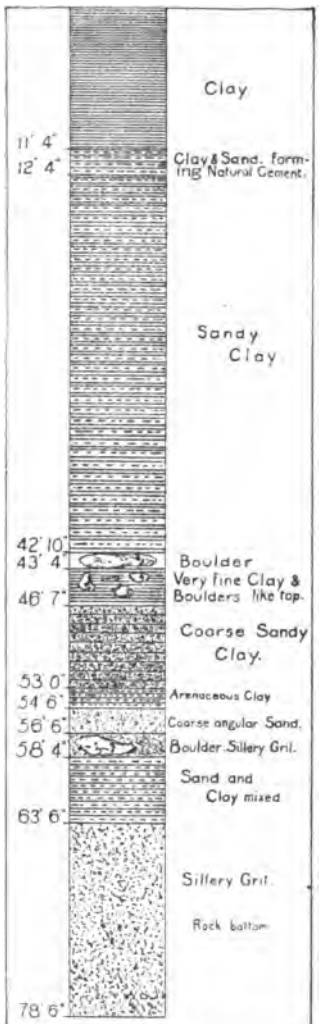
Bore-hole, No. 5. South Side.

One of the limestone boulders contained *Leptœna (Plectambonites) sericea*, Sowerby, indicating clearly the Trenton age of the mass. A typical Sillery grit boulder two feet thick was then struck, whilst the next seven feet are characterized by a mixed coarse and fine gravel with pebbles of clay slate, etc. This material prevails throughout the drillings downward to a depth of fifty feet seven inches whilst the next twenty-six feet five inches, are marked by the presence of well washed quartzose sand with grains of felspar, chlorite, etc., reaching to a depth of seventy-seven feet where the drill stopped.

Bore-hole No. 6.

No. VI Bore-hole. Close to south cliff. South Anchor Pier, 200 ft. from foot of cliff.

Eleven feet four inches of a fine grained homogeneous bluish gray clay characterized the first series of drillings obtained. Below this bed of clay a layer one foot in thickness of a more or less arenaceous and calcareous clay occurred, which, when exposed to the air forms a rather strong natural cement, the grains adhering to one another very firmly, followed by some thirty feet three inches of a more or less pure though at times arenaceous clay. At a depth of forty-three feet four inches a boulder was met with about six inches in thickness, below which occurred three feet three inches of a whitish gray very fine clay, in which a Sillery grit boulder was struck. This clay resembles the first or surface clay described in the drillings from this bore hole. Six feet five inches of a coarse sandy clay, mostly sand follow, below which is a similar stratum eighteen inches thick, forming a comparatively strong natural cement. Coarse angular sand follows two feet in thickness; then a Sillery grit boulder twenty-two inches in diameter, below which are five feet two inches of a coarse rusty sand, continuing to a depth of sixty-three feet six inches. The drill then traversed the solid rock to a depth of fifteen feet. No sample of the rock traversed, however, was present in the drillings, but it is very likely, and most probable that the Sillery grit rocks were struck at the depth of sixty-three feet six inches and penetrated to the seventy-eight feet six inch level, as given in the log accompanying the drillings.



Borc-hole, No. 6. South Side.

NOTE.

In connection with the building of the piers, abutments, &c., of the Quebec bridge, a number of interesting specimens were obtained and forwarded by Mr. M. P. Davis, contractor, through his manager, Mr. A. A. Stuart, to the department for examination, and as donations to the Museum. These include fossil plants obtained from excavations in the caissons both on the north and south slopes of the St. Lawrence river bed, Victoria Cove, Sillery, and samples of rock materials in which these were found imbedded at various depths from the surface. Besides these, a fine block of coarsely crystalline syenite or hornblendic granite employed in the construction of the piers and abutments from the quarries at Riviére à Pierre was also presented by Mr. Davis to the National Museum which serves to illustrate admirably the various characters of this building material so excellent for heavy masonry. Of this rock, Mr. Davis informs me that a single block was quarried which contained not less than 1,900 cubic yards, even and homogeneous in structure throughout. This single block thus weighed no less than 9,069,840 lbs., equivalent to 4,535 tons. The rock is of a light pinkish gray colour, quite pleasing to the eye, and takes a high polish, dresses and cuts well, constituting in a marked degree a highly desirable rock for heavy works and foundations.

Interesting specimens discovered.

Building stone.

Geology of the Site of the Quebec Bridge.

Early in October, with a view of determining the rock materials and geological formations upon which the abutments, anchor piers and main piers of the Quebec bridge rested, the Engineer in Chief and Deputy Minister of Railways and Canals presented a request that I should make a report upon the same. The result of the examination made by me from during field-work of 1901, of the drillings obtained from the diamond drill bore-holes, along the shore and in the bed of the St. Lawrence river at Victoria Cove, Sillery, eight miles above Quebec city, were verified and a report prepared, which has been transmitted to the Department of Railways and Canals and a duplicate copy of the same was deposited with the Acting director of this department, and reads as follows :—

Preliminary Report on the Geological Formations in the vicinity of the Quebec Bridge Piers and Abutments, Victoria Cove, Sillery, Que.

From the examination made of the materials obtained from within the caisson of the south main pier of the Quebec bridge, as well as of

the geological formations along the north and south shores of the St. Lawrence river at Victoria cove, Sillery, Que,, I am led to conclude that there are at least three distinct geological formations upon which the abutments, anchor piers and the north and south main piers rest, in the following ascending order of succession and of age :—

I. The Sillery grit formation.
II. The boulder clay or glacial drift formation.
III. The later Pleistocene formation.

THE ABUTMENTS.

The abutments of the Quebec bridge, both on the north and south shores of the St. Lawrence river, rest directly upon the Sillery grit formation.

This Sillery grit formation consists for the most part of greenish drab-weathering and greenish-gray sandstones or coarse grits frequently assuming the character of fine conglomerates with white quartz pebbles at time the size of peas.

These sandstones are sometimes slightly micaceous, and occasionally hold scales of green and black shale, and a few spangles of graphite. They are often calcareous. They usually present massive beds, and at Sillery, the type locality, many of the layers are quarried for building purposes, the stone being used largely in Quebec city. When broken, the rock presents a sharp, cutting edge and fracture, the grains of material composing the rock being strongly cemented together.

THE ANCHOR PIERS.

The north anchor pier rests directly upon the Sillery grit formation.

The south anchor pier rests in the upper strata of the later Pleistocene or boulder sand formation, which at this point consists for the most part of fine clay and sand filling the interstices of rounded, water-worn and sub-angular boulders of Archæan and Palæozoic formations, such as are seen strewn on the beach at low water, held in a matrix of stratified and well washed sand. The Archæan boulders are as varied in composition, comprising as the rocks of that primitive series the Laurentian and Huronian systems as they are developed in the province of Quebec, including many eruptives.

THE MAIN PIERS.

The materials obtained from within the caisson of the south main pier indicate the presence of both 'the boulder clay or glacial clay' formation, and the 'sand and gravel formation' or later drift.

The boulder clay or glacial drift formation occupies by far the greater portion of the area upon which the south main pier rests.

This 'boulder clay' is the characteristic 'till' or glacial clay of geologists, the 'hard-pan' of Canadian and other American engineers. It was deposited here at a remote period during the Glacial Epoch of geologists.

This formation consists of an indurated, compact, tough and unstratified rock-mass, composed of rounded, angular and sub-angular boulders and pebbles of Laurentian and Archæan gneisses and quartzites, associated with numerous boulders and pebbles of typical Sillery grit, sandstones and shales (of which materials the Sillery formation is composed), besides well-scored and striated or glaciated pebbles of limestone derived from the Trenton and Black River limestone formations of the north shore of the St. Lawrence, all cemented by an argillaceous paste, and held compactly together.

The materials, however, that were obtained from the two most westerly compartments within the caisson, consist of the 'boulder sand and gravel formation.' Rounded and sub-angular boulders and pebbles of Sillery grit and sandstones, of limestone, quartzite, gneisses and various other materials (not differing materially in character and composition from the boulders and pebbles constituting the boulder clay formation), are held in a matrix of sand, which, upon examination, appears to consist of well washed and fine grains of quartz, with occasional grains of hornblende and other impurities.

This sand and gravel formation is of later date than the 'boulder clay' or glacial drift formation, and was no doubt derived from the same, and is a stratified deposit.

THE NORTH MAIN PIER.

The north main pier rests upon the sand and gravel formation. From the materials obtained from within the caisson of this pier, it is evident that the boulders of gneiss, granite, quartzites and limestone, &c., which constitute this formation, have their interstices filled with sand and gravel, and that the whole is of sedimentary origin, of later date than the 'boulder clay or glacial clay' formation, and probably derived from it for the most part, being deposited as modified and stratified drift.

(Signed) H. M. AMI.

Geological Survey of Canada,
Quebec, Que., October 10, 1902.

The following communications from the Deputy Minister of Railways and Canals and from the Secretary-Treasurer of the Quebec Bridge Company, have been received in the department:—

I.

DEPARTMENT OF RAILWAYS AND CANALS.
OFFICE OF THE DEPUTY MINISTER AND CHIEF ENGINEER,
OTTAWA, ONT., October 10, 1902.

My dear Dr. AMI,

I have to acknowledge the receipt of your most able and interesting report on the geological features of the site and vicinity of the railway bridge in course of construction over the St. Lawrence near Quebec.

The information you have been good enough to supply me with, is precisely what I required, and I shall not be under the necessity of availing myself of your kind offer to supplement your report with further details.

Please accept my thanks.

I remain, dear Dr. Ami,

Yours sincerely and obliged,

(Signed) COLLINGWOOD SCHREIBER,
Chief Engineer.

II.

Dr. H. M. AMI, M.A., D.Sc., F.G.S.,
Commission géologique du Canada,
Ottawa.

Cher monsieur,—J'ai en effet reçu, hier du Département des Chemins de Fer, copie de votre excellent rapport sur les formations géologiques des excavations du pont de Québec, et vous remercie infiniment pour la part que vous avez prise à cet envoi.

Votre bien dévoué,

(Signé) ULRIC BARTHE,
Secrétaire-trésorier.

GENERAL REPORT ON THE WORK OF 1902.

(Dr. R. W. Ells.)

The office-work during the winter of 1901-2, comprised a rough compilation of the notes and surveys made in the Kingston district, chiefly by my assistant Dr. R. Hugh Ells, B.A., and the preparation of the reports and geological maps pertaining to the Ottawa river area, west of Ottawa city, and comprised in map-sheets Nos. 119 and 122. Office work 1901-1902.

In May, 1902, a few days were spent in company with Dr. R. Chalmers, in an examination of certain points connected with the work of the late Mr. N. J. Giroux, formerly of this department, in the county of Glengarry, Ont. On June 10, I left Ottawa for Prince Edward Island, to examine the geological conditions in that province, relative to proposed borings for coal. This investigation extended from June 11 to July 17. The report on this examination is appended. Work in the summer of 1902.

At the close of this work, I proceeded to Gaspé basin to examine the structure of the Gaspé oil-field where boring operations, looking to the finding of oil in paying quantities, have been carried on continuously since 1889, by several companies. The principal work has been done by the Petroleum Oil Trust, Ltd. of London, Eng., by the Canada Petroleum Co. of Manchester, Eng., and by the International Oil Co. of St. Paul, Minn. Every facility for a thorough investigation of the district was afforded me, as well as an examination of all logs of borings, pumping output, records, etc., connected with the operations of the several companies, copies of all which were obtained. All the localities where wells have been sunk were visited, and a copy of the office plan of the Petroleum Oil Trust was made, on which the sites of all borings are indicated. Attention was paid to the geological structure of the basin in which the oil occurs, and the presence of several important lines of faulting was determined. These evidently traverse the area from north-west to south-east and are sometimes found closely associated with the several lines of anticline in the district. A report on the work has been prepared, showing the nature of the work al eady done and the output of the several wells from the commencement of boring operations, which is also herewith submitted. The Gaspé oil-field.

At the close of my work in Gaspé I returned to New Brunswick on Aug. 12, a d in company with Mr. H. S. Poole of Halifax, visited some points of geological interest relative to our work in the south-eastern portion of the province. In this connection we examined the works of the Intercolonial Copper Co. near Dorchester, Work in New Brunswick.

and the oil wells of the New Brunswick Petroleum Co. near Memramcook and in the township of Hillsborough. Several sections were made of some of the divisions of the Lower Carboniferous formation, and some time was spent in studying the rocks of the Upper Carboniferous formation as developed about Bay Verte and in the Tormentine peninsula, in order to, if possible, obtain certain data with regard to the thickness of that formation as seen on Prince Edward island.

Kingston area.

I returned to Ottawa on Aug. 26, and, after a week spent in the office, proceeded in company with Dr. Whiteaves, to the Kingston district in order to complete some details of work left over from the previous season. In this connection several localities of special interest were visited, as possibly affording characteristic fossils for determining doubtful points of structure in this area, and several good collections were obtained. We returned to Ottawa on Sept. 11 and on the 24th I again proceeded to New Brunswick, where, in company with Mr. Poole, an investigation was made of the Albert shale deposits found in Albert and Westmoreland counties, with a view to ascertain their value as a possible source of supply for oil by distillation. The report on this work is also submitted. I returned to Ottawa on Oct. 4.

Albert shales.

Work by Dr. Hugh Ells.

In connection with the work on the Kingston sheet my assistant Dr. R. Hugh Ells proc eded to that area fr m Gaspé on July 28. Surveys were carried on till Sept. 23, and these have been plotted ready for compilation. The area in which these were chiefly made is ounded on the east by the line of Hastings county and on the west by the line of the Kingston map-sheet, No. 112, which extends northerly from the Bay of Quinte, at a point about five miles west of the city of Belleville, through Madoc into the townships of Elzevir and Grimsthorpe. These surveys connected the work of the last season with that done in 1884 by Mr. E. Coste in the Marmora and Madoc district, and with that done by myself in 1896 in the townships of Clarendon, Barrie and Anglesea.

The Oil Fields of Gaspé.

Dr. R. W. Ells.

Early work in Gaspé.

The several reports on the rocks of eastern Gaspé in which area the oil fields of hat district are located, date back to the year 1844. The examination of this area was first made on behalf of the Geological Survey by Sir W. E. Logan the director, and by his assistant, Mr. A. Murray. In the reports for that year mention is made of the occur-

rence of oil springs at several places in the district traversed by the lower portion of the Dartmouth, the York and the Douglastown rivers.

Devonian rock section.

The section published by Sir William Logan of the strata seen along the shores of Gaspé bay and basin gives a very fair description of the rock formations which occupy the eastern portion of the peninsula. They consist largely of grayish sandstones, interstratified with grayish and sometimes reddish or brown shales, and the whole thickness given for the rocks of the series, which are of Devonian age, is about 7,000 feet. Beneath these rocks is a series of limestones which have a thickness estimated at 2,000 feet. These contain fossils in their upper portion which indicate a passage between the Devonian and Silurian systems.

The geological aspect of all these formations has already been very fully discussed in the preceding reports of this department, so tha it will not here be necessary to allude further to this aspect of the question.

History of oil investigation.

The cause of the investigation leading to the following report was the determination of the problem as to the economic occurrence of oil in this district. For some forty years investigations tending in this direction have been in progress by various companies, and several reports on the industry have been written. The early operations by boring were without practical result, but about 13 years ago renewed attempts were made to thoroughly explore the area. In this work, which is still being prosecuted, a large amount of money has been spent, largely in boring operations, and an amount of capital expended reported at over a million of dollars. Much of this work was done by the Petroleum Oil Trust with headquarters in London, England, and later by the Canadian Petroleum Co., with head quarters in Manchester. Other borings were made by the International Oil Co., of Minneapolis, and in all some 52 wells have been sunk, the depths in some cases reaching 3,700 feet.

Wells sunk

Of these thirty-nine wells have been put down by the Petroleum Oil Co., twelve were sunk by the Canadian Petroleum Co., one by the International, and two others representing the borings of the early days were sunk, one at the summit of the ridge near Sandy Beach, the other inland about seven miles above Gaspé basin near the oil spring on Silver brook.

Comparison with rocks of Pennsylvania.

Comparisons have been made from time to time between the areas in Gaspé and those of the oil regions in Pennsylvania, and the state-

ment has been repeatedly made that the localities are geologically similar and the conditions for oil production practically the same. In so far as the geological horizons are concerned there may be some truth in these statements, since the oil territory in both cases is regarded as being in Devonian rocks. Otherwise the comparison fails in some important respects, as will be presently pointed out.

Early views as to the Gaspé oil basin.

Reference is made in the prospectus of the company (Petroleum Oil Trust) to opinions expressed nearly forty years ago by such eminent authorities as Sir W. E. Logan, Dr. T. Sterry Hunt, Dr. Robert Bell and others. In so far as any direct expression of opinion from these reports is concerned it is difficult to find anywhere any pronounced statement that the territory is eminently oil-producing. In point of fact no such opinion could then have been well put forward, for with the exception of the occurrence of small oil shows in the form of springs, and the fact that certain shale bands were of a bituminous nature, nothing further was then known. In those early days also neither the nature of oil-bearing rocks nor the conditions which govern the occurrence of oil in profitable quantities, were so clearly unerdstood as at the present day, so that the favourable notices thus quoted must be taken with a great deal of reserve.

Unfavourable conditions for oil.

The conditions governing the present occurrence of oil in all recognized oil-fields to-day show that the strata as a rule must lie in a nearly horizontal attitude, or affected by slight undulatious, the amount of dip rarely exceeding two or three degrees. Such are the conditions seen in the oil fields of western Canada (Ontario), in the eastern and central states, and in the oil fields of Colorado, where however the geological horizon belongs to a much more recent date, viz., to the Cretaceous system. In no case has oil in paying quantities been found in America in rocks which are much tilted and broken, though indications of oil are quite common under such conditions and even small quantities are found on boring.

Anticlines.

The area in which boring operations have been carried on in Gaspé extends in a north-westerly direction from Seal Cove, on the south side of Gaspé bay, to Falls brook, a branch of the York river on the north, in a direct line, thirty-three miles distant. The district is traversed by several lines of anticlinals which have a generally north-west course from the shore of the Gulf of St. Lawrence. Of these, the most northerly comes to the coast at Cape Haldimand, which is between Sandy Beach and the Douglastown barachois or mouth of the St. John river. This has been named the Haldimand anticline.

Going south, the next line of anticline comes to the coast, near what is known as Tar point, on the south side of Gaspé bay and is known as the Tar point anticline. The third, known as the Point St. Peter anticline, comes to the sea at a point between Malbay and Gaspé Bay, while a fourth comes to the shore at or near Percé. Tar point anticline.

Good sections are afforded along the south side of Gaspé Bay from Point St. Peter north-west to Gaspé basin. Fairly good exposures are also seen along the several rivers which traverse the district from the west, including the Dartmouth, the York and the St. John or Douglastown.

The surface of the country, a short distance inland, is usually very rugged, with high ranges of hills, reaching in places, elevations of 1,200 to over 1,500 feet. The country itself, is generally densely wooded and except along the lower portion of the several rivers entirely unopened for settlement. Owing to forest covering, and the heavy deposits of drift, which are found over much of the area, good rock exposures are rarely met with off the lines of the principal streams. On many of the side streams also, the banks are composed of clay, gravel or other drift. The thickness of these drift deposits has been found in some of the boring locations to be nearly 100 feet. Rough character of country.

An examination of the shore section shows that horizontal strata are rarely found. Generally the sandstones and shales are tilted at a comparatively high angle, in some places as much as 65 to 70 degrees. Faults are found at intervals not only along the shore section, but can be readily recognized on the rivers, and the strata are here in places at angles of 80 degrees. Inclined strata.

The course of the several anticlines has been traced by numerous traverses as carefully as was possible. The underlying limestones have in many cases been assumed to represent these, especially where sandy strata are seen on either side. On the south side of the Dartmouth, the sandstones are inclined at angles as high as 80 to 90 degrees, and probably an overturn of the formation occurs between L'Anse à Cousin and the mouth of the Dartmouth. Faults are also observed at several points.

Of these faults, at least four well-defined ones occur on the shore section between Point St. Peter and the mouth of the Douglastown river. On the shore at the Narrows to the inner basin at Gaspè village, there is also a dislocation in connection with the anticline by which the beds are tilted at a high angle. Faults.

Inland th s faulted character is observable at several points. Thus near the International Co's boring on section 41, north of the York river, a well-defined break is seen, by which the underlying limestone of Silurian age is brought sharply against the Devonian sandstone. At this break there are several oil springs, one of which is of large size, and these appear to owe their existence to this line of fracture. This line of fault can be traced south-east across the York and the St. John rivers, separating sharply the limestones from the sandstones and it is possibly continuous to the shore north of Malbay.

Oil springs in fault lines.

It is very probable that most of the oil springs of the district are situated along lines of fracture, and in fact this feature is well seen at several points. The break which crosses the upper part of Gaspé basin at the village, is probably continuous to the north-west along the south side of the range of hills which occupy the area between the lower part of the York river, and the lower part of the Dartmouth, and a small oil-spring is found on this projected line of break, about three miles west of the village. From the high dips at the oil-spring south of Sandy beach where strata are inclined at an angle of 70 degres, it is probable that this break continues eastward near the line of the Haldimand anticline, since there is also a spring near the shore on its course, just inside the head of the bar at the Douglastown barachois.

From the abrupt changes of dip seen along the St. John and York rivers at several points where the amount of inclination suddenly changes from 10 to 80 degrees, it would appear that these breaks are more frequent than has usually been supposed. In such a folded, inclined and faulted series of strata, therefore, one would scarcely expect to find highly favourable conditions for a productive oil-field, and this inference appears to be well sustained by the investigations of the last 12 years.

Conditions for the occurrence of oil.

In considering the question of the occurrence of oil in Gaspé in paying quantities, therefore, several conditions must be observed. First, the occurrence of true oil-bearing strata ; 2nd, the favourable position or otherwise of such strata for the retention of oil if such ever existed in quantity ; 3rd, the occurrence of faults and overturned rocks ; 4th, the occurrence of anticlines along which the oil is supposed to occur.

As to the first proposition it may be said that while oil springs are found at several points throughout the area, the rocks of the formation, as seen along the numerous coast and river sections, do not display oil at any point with the exception of the small quantities found in portions

of the dyke of intrusive rock which penetrates the Devonian sandstones near Tar Point. These sections furnish a good representation of the sandstones and shales of the formation from the bottom to the top. At the same time it must be admitted that oil in small quantity does exist in some portion of these sediments, since it has been found in several of the bore-holes.

In the second place the tilted and faulted character of the rocks throughout the greater part of the Devonian basin, both of eastern Gaspé and along such rivers as the Bonaventure and the two Cascapedias to the west, are unfavourable to the occurrence of oil in quantity, while the several faults which traverse the strata along which the oil springs presumably occur would serve to carry off along certain lines any small quantities of oil that might locally occur.

And, thirdly, the anticlines, instead of being in low, gently inclined strata are usually sharply defined; the inclinations of the opposing sides are often steep and the axes probably complicated by faults, as can be seen in several cases.

Anticlinal theory.

In the course of the recent examination of the area special attention was paid to the occurrence of such features as faults and anticlines in order to see if the theory usually put forth that the productive oils are found along anticlinal crowns was maintained in this area. As a result it may be stated that such application cannot be made for the Gaspé district. A number of deep bore-holes were sunk on or very near the line of axis of several of the anticlines without finding oil at all, or in but very small quantity, while some of the wells which were put down near the centre of the synclines are recorded as much more productive. In fact from the records of the numerous wells those bored in the central portion of the basins are practically the only ones that have yielded oil in appreciable quantity.

Kinds of oil found.

The oils found are of two kinds, viz., a light amber oil which has been obtained from the upper or sandy portion of the formation, and a dark green heavier oil which was obtained usually from the lower or calcareous underlying rocks. It may here be stated that the supposed horizon of the oils would be found about the contact of the sandstones and limestones; and while in some wells there was a small showing at such places, in many cases this line was passed without any result as to finding the oil. Under such circnmstances the difficulty of locating wells, with any certainty of finding oil in paying quantity, may be readily imagined.

Acknowledgements.

In my investigation of the district I may state that every facility was afforded me by the resident agent, Mr. Sutton LeBoutillier, and by the resident engineer, Mr. C. R. P. Hillary. I was also supplied with logs of all the wells from the commencement of boring operations, and in cases where the pumping plant was in place the wells were pumped for a time and the present daily capacity of each ascertained.

Records of Borings.

Boring record.

My work was also greatly facilitated by the use of a plan in the company's office in which all the wells were located and which was placed at my disposal. The resident manager of the Canada Petroleum Co., Mr. Wheeler, also rendered me great assistance, giving me all possible information as to the logs of their wells and fixing their position on the plan of the district. To all these gentlemen our thanks are due for the courtesies extended.

The Sandy Beach wells.

The earliest boring made in the district for oil was located on or near the crest of the Haldimand anticline about one mile south of the shore above Sandy Beach, at an elevation of 210 feet above sea level. This was in close proximity to the oil spring which occurs at that place.

This first boring was made in 1866 by Messrs. Conant and Hubbard, well drillers from Pennsylvania. Their log is given in the prospectus of the Petroleum Oil Trust, and may be briefly summarized thus :—

First well sunk 1866.

Drift, about 25 feet. In this a small quantity of oil, probably from the adjaçent spring, was found in the gravel.

In the boring proper a small vein of oil and gas was reported at 83 feet from which about one gallon of the former was obtained. At 238 feet a small showing of thin light oil with salt water was met, and traces also occurred at a depth of between 425 and 430 feet, not sufficient, however, for pumping. At 444 feet oil was again reported and again at 600 feet. At 684 feet the tools were lost, and after several unsuccessful attempts to recover these the boring was discontinued. A quantity of oil was obtained, by pumping which, it is said, in nine hours produced 25 to 30 barrels of oil, of 'a beautiful dark greenish colour.'

Work of the Petroleum Oil Trust.

No further attempt to exploit this area was apparently made until the advent of the Petroleum Oil Trust. On November 19, 1889, boring was commenced and continued with many interruptions to January, 1891, when a total depth of 2,430 feet was reached. Much delay was caused by heavy flows of salt water at, 1,325 ft. and again at 1,700 ft., which

required casing off. Oil was reported in small show at 2,048 ft. and again at 2,400 feet, and pumping was resorted to but no oil was found.

Three wells were sunk by the company at this place which are known as wells No. 2, 3 and 8.

Well No. 2 was commenced on May 1, 1890. The depth reached on October 16, was 2,582 ft. Water was struck at several points, and three small shows of oil were reported at about 500 feet, at 965 feet, and again at the bottom, but all of no importance. The well was shot four times, viz, at the bottom, at 2,036 feet, at 1,200 feet and at 900 feet, but no oil was obtained, and no further work was done. Well No. 2.

The log of well No. 3, located at the Douglastown beach near the head of the Bar, is very incomplete. It was commenced apparently about October 14, 1890, and reached a depth of 2,225 feet. Salt water was found at 1,304 feet and no oil was reported. Well No. 3.

Well No. 8 was begun on November 8, 1892. Salt water was struck at 745 feet, at 936 feet, at 1,175 feet and at 1,450 feet, and was successfully cased off. The rig was burned down and subsequently rebuilt, but the difficulty found in sinking was such that the hole was soon after abandoned and no oil was recorded. At present there is no oil in any of these wells. Well No. 8.

It may be said that all these four wells, Nos. 2, 3, 8 and that of 1866, are located within a very limited area. The rocks are highly inclined and there is probably a fault in this direction. The record of rocks passed through is very incomplete, except that they consist of grayish sandstones and shales with some purple or reddish bands, similar to the sediments seen in the coast section at Cape Haldimand. Being situated on the crown of the Haldimand anticlinal and in the immediate vicinity of one of the largest oil-springs in the district it was supposed that the locality was especially favourable as regards the finding of oil in paying quantity. The expectation however, was not realized. Rocks passed through.

Well No. 4 is situated on or near the Tar Point anticline. The locality is about 100 feet above sea level and about half a mile from the shore of Gaspé bay. Well No. 4 at Tar cove.

The log is incomplete as regards details. The rocks passed through were all sandstones with beds of shale, such as are seen along the shore east of Seal Cove. The drilling is reported as good to a depth of 2,540 feet when hard rock was encountered, and in this it was continued to a total depth af 2,970 feet when the tools were stuck and

could not be recovered. A small show of oil was reported, though of no importance, at 2,215 feet, but there was nothing to warrant further investigation at this locality apparently, and no further attempts were made at this place.

Well No 5, west of Gaspé village.

Well No. 5 is the first of a series bored in an area about 7 miles west of Gaspé village, on the north side of the York river. It is near the line of the main road up the river leading to Silver brook. The log is very incomplete and the date of boring is not stated except 1891-92. The total depth reached was 2,640 feet. At 1,850 feet a small show of oil was reported and at 2,360 feet a small show of green oil also. Limestone was struck at this depth and continued down to 2,458 feet; and on September 27, 1891, the tools were lost in the hole, and not recovered. No oil was found below 2,360 feet. In January, 1892, it is reported that four barrels were bailed out. The well was shot on October 25 of that year without any satisfactory result, only about two barrels being pumped on November 9. It was again shot on December 11, 1893, but gave no further results. This well evidently passed the contact between the sandstone and limestone, at which horizon it was supposed oil would be found. On December 23, 1893, this well is said to have pumped oil, after being shot, at the rate of 2 quarts per day, and the same amount on January 5 and 6, 1894. A small quantity in the water in stand-pipe about 25 feet from the top.

Wells No. 6 and 7.

Well No. 6 was located on the bank of a small brook about 12 miles west of Gaspé village, or 5½ miles west of No. 5. It is in close proximity to a ridge of limestone which crosses the road a short distance west of the location, but though a depth of 3,640 feet was reached, this limestone was not found. It is probably near a line of fault which extends in a south-east direction from the International Co's. property situated about three miles north-west where this fault is well defined, the limestone being brought directly against the sandstone and the dip of the fault being to the south-west. The rocks in this boring are shales and sandstones and only a small show of oil of no importance was recorded at a depth of 2,950 feet. The hole was begun on January 25th, 1892, and work closed on October 22nd of the same year. Salt water was struck at 395 feet, at 440 feet and again at 590 and 690 feet, to which depth the well was cased.

Well No. 7 is in the same area as No. 5 and about half a mile west. It was commenced on October 18th, 1892, and finished on November 21st of the following year. The depth reached was 2,867 feet and the limestone was struck at 2,385 feet, at which point a small show of oil and salt water was struck. Oil was also found at a depth of 2,589

feet and again at 2,650 feet. The boring in the limestone was very difficult as the rock is generally very hard and silicious. From the samples it appears to be a hard silicious dolomite. The well was shot with 200 quarts of nitro-glycerine at 2,589 feet on November 29th, and pumping was commenced on December 15th. Water only was pumped at first, but on December 16th, an amount of oil estimated at 20 barrels was obtained. The pumping log of this well is interesting. On December 19th it pumped about three barrels; on December 23rd an average of about a half a barrel per day. In 1894, January 5th and 6th, this well is said to have yielded at the rate of a half a barrel per day, and on February 14th the bottom hoop of the tank in which the oil was stored burst off and a quantity of oil, estimated at 200 barrels was lost.

Well No. 9 is the only one bored on the north side of the Haldimand anticline. It is situated about one-half mile south of the Dartmouth river and 4 miles west of Gaspé village. The hills to the south are high and composed of limestone, the strata in the vicinity are steeply inclined and near by are faulted and apparently overturned. The well was begun on March 7th, 1894, and reached a total depth of 2,719 feet. The boring continued in sandstone and shale the whole distance. Water was struck at depths of 495 and 560 feet, but no sign of oil was found. **Well No. 9.**

From the position of the limestone hill to the south of this locality it is evident that a heavy fault cuts across the area and brings the two sets of strata in contact at a high angle. The location of this boring was a very bad one. **Heavy fault.**

In the area in which wells Nos. 5 and 7, already described, are located, no less than 13 wells were bored. Of these nine were sunk by the P. O. T. and four by the C. P. Co. They are all situated in a space of about one square mile on the north side of the York river, as per plan, and are for the most part south of the Tar Point anticline, though wells Nos. 15 and 36 are situated near its crest.

Well No. 10 was commenced in January, 1895. It reached a depth of 1,400 feet, the rocks for the entire distance being sandstone with occasional bands of shale. Water and gas were struck at 775 feet and small shows of oil at 1,108 and 1,170 feet. On October 26 the well was shot with 160 quarts of nitro-glycerine at 1,400 feet. No oil was taken out and the well was abandoned on account of water and caving of the sides. This well was near the supposed line of the anticiline. A small quantity of green oil now in stand-pipe. Wells No. 10 and 11.

Well No. 11 is situated about one mile west of the last and about half a mile south of the anticline. Work was started on 29th December, 1893, and the hole was bored to a depth of 2,957 feet, which was reached March 23th, 1895. Sandstone extended down to 2,080 feet, at which point the limestone was struck. At 2,220 feet, in the limestone, gas and oil were reported, and an explosion took place by which the rig was burned down on May 2nd, 1894. The rig was rebuilt on June 24th. Oil flowed and a supposed large quantity was lost during the night, estimated at some hundreds of barrels. The boring was resumed and a small show of oil was again reported on September 7th at a depth of 2,485 feet. The limestone continued to the bottom of the hole without finding any more oil. The rig was again burned on May 13th, 1895, and rebuilt. The well was shot twice in the following September without any beneficial result, and subsequent pumping in October yielded a very small quantity of oil. A little oil on surface of water in stand-pipes, about four feet from surface.

Wells No. 12 and 13.

Well No. 12 is located near the north bank of the York river and about one mile south of the line of the Tar Point anticline. It was commenced in January, 1894, and finished on May 4th at a depth of 3,002 feet. It passed through sandstones and shales for 2,550 feet when the limestone was first struck, and this rock continued to the bottom of the hole. A very small show of oil was reported at depths of 2,075 feet and at 2,837 feet. The well was plugged at 2,830 feet for shooting. It was not pumped and no oil was found worth recording. A very little oil now in stand-pipe on the water about ten feet from top.

Well No. 13 is located a short distance north of the main road and about half a mile south of the anticline. Drilling commenced on September 1st, 1894, and continued to December 26th, when a depth of 2,050 feet was reached. The limestone was not struck and no oil was found. At the bottom the well was overflowing with salt and sulphur water which rendered further drilling impossible. Now flowing salt water.

Wells No. 14 and 15.

Well No. 14 is situated three-quarters of a mile west of the last and about three-quarters of a mile south of the anticline. It was commenced May 4th, 1895, and reached a depth of 2,775 feet on February 13th, 1897, nearly two years being spent on the work. The limestone was struck at 2,265 feet on October 19th, 1895, and the subsequent drilling was very slow, the limestone being very hard. Neither oil, salt water or gas found in this hole, but there is a small quantity of green oil on the water in stand-pipe.

Well No. 15 is situated about ¼ mile south of the anticline. It was commenced on April 1st, 1895, and reached a depth of 2,012 feet on August 17th, the limestone being struck at 1,880 feet. At this depth it is said that about 50 barrels oil were bailed out. Well torpedoed at bottom and fitted for pumping. Yielded continuously about 7 to 8 gallons oil for several months. In spring of 1901 gave about two gallons per day. All work discontinued and nothing done since. A small quantity of green oil on the water in stand-pipe, about six feet from surface.

Well No 36.

Well No. 36 is the most northerly in this area. It is located about ⅛ mile north of the anticline, the position of which can be readily seen on the road up the mountain, the elevation of the starting point being 804 above sea-level. Work was begun on July 9th, 1901, and continued to December 4th, to a depth of 1,950 feet. The limestone was struck at 1,780 feet, the rock above this being, apparently, for the most part sandstone. Salt water was struck at 1,065 feet, and was met with at intervals to the bottom. No trace of oil was found in this hole.

Wells of Canada Petroleum Co.

Of the four wells bored by the Canada Petroleum Co. at this place numbered 3, 7, 9 and 10, the following notes were furnished me by the resident manager, Mr. Wheeler.

Well No. 3, started August 15th, 1899, finished November 11th, reached a depth of 2,240 feet. Limestone struck at 2,230 feet. No oil.

Well No. 7. Date of boring not given. Depth 2,063 feet. Limestone at 2,046 feet. Oil reported at 1,945 feet. Took out from 2 to 3 barrels only.

Well No. 9. Depth 2,226 feet. Limestone at 2,212 feet. No oil found, but water in large quantity at 1,132 feet.

Well No. 10. Depth 2,383 feet, limestone at 2,360 feet. No oil found in boring, but in July, 1901, a quantity reported at 3 barrels, was obtained, and there is a little at present in the stand-pipe.

Wells of the 2nd group.

Another group of wells is situated on block 40, on the north side of the York river, near the junction of the Mississippi branch. This group included about 23 wells, the of which are comprised in an area of about one square mile. Of these, the Canada Petroleum Co. put down seven. A tank for a pumping station was also erected at this place, and connected by a pipe-line eleven miles long, with a refinery which is located on the bank of the river, about seven miles west of the village of Gaspé Basin, in the group of wells just described.

Campbell well and well No. 16.

Several intermediate wells were located between these two principal areas, of which that known as Campbell's, on the bank of Silver brook, was one of the first bored. It was located near the oil spring which is described in Logan's report as occurring in that district. No log of this well exists, but apparently no oil was found in the boring, which is placed at some distance south of the line of the Tar Point anticline.

Well No. 16, bored by the Petroleum Oil Trust, is about two miles west of Silver brook, and about one mile north of the main road up the York river. It is near the foot of a high ridge which rises to the north. The elevation is 510 feet above sea-level. The boring commenced on January 26th, 1895, and ended August 17th of the same year. The depth reached was 2,995 feet, and the limestone was struck at 2,880 feet. Only one small show of oil was found at a depth of 2,664 feet. Not much salt water was met with, and no oil was taken out. This place should be about the middle of the syncline between the Tar Point and Point St. Peter anticlines.

Well No. 17.

The wells of the second group lie to the south side of the latter anticline. Of these, well No. 17 was commenced on March 30th, 1895, and finished on June 26th, 1897, over two years being occupied in the boring. The hole reached a depth of 2,550 feet, the limestone being struck at 2,000 feet. Great difficulty was experienced in boring the limestone, which caused the delay. In all, only one and a half barrels of oil was taken from this hole, though oil was reported at depths of 1,013, 1,045, 1,200 and 1,286 feet. The reported bailing of oil was from a depth of 2,348 feet.

Wells, No. 18 and 19.

Well No. 18 was begun on August 24th, 1895, and finished on June 9th, 1896, at a depth of 1,960 feet. The limestone was struck at 1,865 feet, the rocks to this depth being sandstones and shales. A very small show of oil was found at 990 feet, and at 1,095 feet. This well was shot with twenty-five quarts of nitro-glycerine, but no oil was found in the boring. There is now a small show at the top of the stand-pipe.

Well No. 19 is located about three-quarters of a mile north of the York river, at an elevation of 355 feet above sea-level. It was commenced on November 7th, 1895, and finished on April 16th, 1896, at a depth of 2,340 feet at the contact with the limestone, the boring being in sandstone and shale all the way. Salt water was struck at 700 feet and again at 1,500 feet. The first small show of oil was found at 1,185 feet, a second show at 1,792 feet, and a third at 2,050 feet. No oil was found at the contact with the limestone. On August 1st, after taking out about ten barrels of amber oil, the well was shot with 100 quarts of

nitro-glycerine, at a depth of 2,040 feet. On August 5th, after cleaning, the well produced about one-half barrel of oil per day for a time, and on August 25th, it was tubed and connected with tank. It is reported to have yielded one-half a barrel of oil per day for a few days, which then reduced to ten gallons, and in 1902, (August) yields by pumping, from two to three gallons per day.

Well No. 20 is situated about half a mile north-west of the last, and nearer the anticline. The elevation at the surface is 442 feet. The boring commenced on January 1st, 1896, and continued to June 30th at a depth of 2,050 feet in sandstone, when a small vein of oil and gas was struck. It was afterwards continued to a depth of 2,173 feet in limestone. It was shot with 100 qts. of nitro-glycerine at 2,059 feet without beneficial results, only half a barrel of oil being bailed in 24 hours. On August 5th it was tubed and pumped, and gave about five gallons a day for a time, and in July, 1902, it yielded from half to one gallon per day. Salt water was struck in the boring at 595 feet. This oil seems to have been met near the contact of the sandstone and limestone. Well No. 20.

Well No. 21 lies about half a mile north of No. 20, and near the axis of the anticline. The elevation is 780 feet. Boring began on April 24th, 1896, and ended on June 12th, 1897. The limestone contact was met at 1,555 feet where there was a strong smell of gas and a very small trace of oil which was of no importance. No salt water was reported, and the drilling in the limestone was very difficult. The boring reached a depth of 1,830 feet without any urther showing of oil and the work was abandoned. The limestone throughout is reported as fine-grained and very hard. No oil was extracted. Wells, No. 21 and 22.

Well No. 22 is located in the eastern area, north of group one, near the crest of the Tar Point anticline and at an elevation of 1,000 feet. This boring proceeded in sandstone and shale to a depth of 2,750 feet when the limestone was reached. It was then carried down to a total depth of 3,130 feet in the limestone. The boring began on April 1st, 1896, and ended on July 22nd, 1897. No oil was observed at the contact and the first small show was met at a depth of 2,945 feet, with water and gas. On March 20th, 1897, a large vein of gas and oil was reported at the contact with a white sand at a depth of 3,105 feet and strong brine was struck at 3,107 feet. A pumping plant was then installed and operated till June 19th. The pumping log shows some points of interest. Thus, on April 5th, a good show of oil was found in water. On the 22nd half a barrel of oil was taken out, and on the 23rd four barrels of oil. On the 26th three barrels of oil, and on the 29th the same amount. On the 30th only two barrels of oil were obtained,

and on May 3rd this was reduced to one barrel, on the 4th to half a barrel, on the 8th, it yielded one barrel and a half. On the 15th the oil lessened in quantity and was less than half a barrel per day. On the 28th it yielded one barrel of oil, on the 29th three barrels, on June 5th, two barrels, and on the 12th one and a half barrels. On the 16th only a pail of oil with water was obtained and drilling commenced again after pulling tubing. On July 13th more water was struck, and on the 22nd the well was abandoned. This well apparently tested the anticlinal axis better than any of the previous ones. The location was near the upper part of Silver brook.

Well No. 37. In the vicinity of the same anticline two other wells were put down at a later date, viz., Nos. 37 and 38. Of these No. 37 was situated near the axis of the anticline but a short distance on the south side. The elevation was 917 feet and the thickness of the drift was 73 feet. Bands of hard limestone were struck at 455 feet and continued down to a depth of 645 feet. Below this to the bottom of the hole, at a depth of 2,600 feet the rocks were all sandstone, which were calcareous for the last 200 feet. A small showing of green oil was reported at 2,218 feet, from which about two barrels were taken, but none was found below this point. The boring began on September 18th, 1901, and ended on March 15th, when the work was discontinued. The occurrence of the limestone in the upper part of this boring is interesting. Salt water was struck at 927 feet and 1,875 feet, and gas at 1,925 feet.

Well No. 38. Well No. 38 is located about one mile east of the last at an elevation of 887 feet, and also on the south side of the anticline not far from its crest. The boring began on November 20th, 1901, and ended on March 14th, 1902, at a depth of 2,089 feet. The boring was in sandstone throughout, but the rock was somewhat calcareous in the last 50 feet. A very small show of oil was reported at a depth of 2,030 feet, which was the only indication observed. Salt water was struck at 955 feet, and much trouble occurred from this cause at 2,000 feet, so much so that operations were suspended. No oil was taken from this well and the underlying limestone was apparently not reached.

Wells, No. 23 and 24. Two holes, Nos. 23 and 24, were put down on the south side of the St. John river about seven and eight miles west from the mouth. The drift in the first was heavy, amounting to 52 feet. Drilling began on Aug. 4th, 1896, and ended at a depth of 1,790 feet on May 26th, 1897. The sandstone continued down to a depth of 1,480 feet to the limestone. Heavy salt-water was struck at a depth of 1,670 feet, and the well was cased to 1,690 feet. Owing to the difficulty of penetrating

the limestone boring was abandoned at 1,790 feet and no trace of oil was noted. The elevation of this well is 160 feet above sea-level.

Well No. 24 is about one mile west of the last. The elevation is 300 feet and it is a short distance north of a high ridge of limestone. It was commenced on January 10th, 1896, and work ended in May at a depth of 1,230 feet. The sandstone was very thin at this place and the rock was mostly a very hard limestone to the bottom. The hole having become crooked was abandoned on account of the difficulty in penetrating this rock, No trace of oil was observed in this boring, and it is possible that a line of fault running between these two holes, traverses the area in a south-east direction.

Well No. 25 is located at Fourth lake, about midway between the St. John and the York rivers, on block 44. It should be about the central portion of the area between the Point St. Peter and Malbay anticlines. The elevation of this hole was not taken, but is not far from 200 feet. The depth of the drift at this place was 63 feet. Work was commenced on December 2nd, 1895, but owing to difficulty in getting to bed rock, drilling did not commence till August 14th of the following year. It continued till July 10th, 1897, when a depth of 1,230 feet was reached. The log gave sandstone for 605 feet to limestone, which thence continued to the bottom. There was no show of oil in this boring. Well No. 25.

Well No. 26, situated near the St. John river at an elevation of 96 feet, was begun on February 13th, and finished on September 29th, at a depth of 2,900 feet according to log, though samples of borings are on file to a depth of 2,978 feet. No oil was found in this hole. Sandstones and shales continued down to 2,200 feet to the limestone, and from this to the bottom the rock was, for the most part, limestone with occasional sandy layers. A little gas was struck at 1,700 feet, and also at 2,550 feet. The hole ended in sandstone and limestone according to the samples, but the log registered limestone only. Wells, No. 26 and 27.

Well No. 27 is located in the second group of wells, north of York river. It was commenced on February 28th, 1897, and bored to a depth of 1,467 feet in sandstone with occasional bands of pebble conglomerate, the pebbles being mostly white quartz. At this depth a vein of oil and gas was struck in the conglomerate which is said to have flowed three times before being plugged. This oil was all lost. The well was subsequently carried down to a depth of 2,200 feet, and a considerable quantity of oil taken out and tanked. These tanks were burned in June, 1898, the quantity of oil destroyed being estimated at several hundred barrels. After deepening the hole no other large

quantity of oil was found though the limestone was reached, and the well is now pumping (July, 1902) about two gallons per day. The location is about one mile south of the supposed crest of the Point St. Peter anticline, and the elevation is 230 feet.

Well No. 28. Well No. 28 is situated on the line between blocks 38 and 39, near a small stream which flows into the York river. It is about five miles west of the last, and about two and a half miles south of the anticlinal. It was begun on June 19th, 1897, and the rig burned down on July 22nd. This was rebuilt, and drilling began again in September, and continued till June 7th, 1898, to a depth of 3,525 feet. The hole was in sandstone and shale for the entire distance, the limestone not being reached. No oil was found, but salt water was struck at 1,100 feet, which is now flowing from the pipe. The elevation of this hole is 920 feet.

Well No. 20. Well No. 29 is situated in the second group of wells a short distance north of the York river at an elevation of 130 feet. It was commenced on November 27th, 1897; the drift was 61½ feet deep. It reached a depth of 2.600 feet in October. A little gas and oil was reported at 2,180 feet, and salt water at 840 feet, at 1,209 feet, at 1,380 feet and at 1,450 feet. The limestone was not reached and the hole was abandoned in shale and sandstone. At this well the central collecting tank for the area is located, and from this point the pipe-line of eleven miles extends down to the refinery at the first group of wells, about seven miles west of Gaspé village. A pumping station was also erected, and in the tank there is at present a quantity of amber oil, estimated at from 200 to 250 barrels.

Well No. 30. Well No. 30, is located one and a quarter miles north-west of the last, near a small brook about one mile north of the York river, the elevation being 215 feet. It was begun on June 24th, 1898, and ended January 20th, 1899, at a depth of 1,580 feet. No oil or gas was found in this hole, which was sunk in sandstone for the entire distance, but salt water was very abundant and was struck at 860 feet, at 930 feet, at 1,022 feet, at 1,075 feet, at 1,150 feet, at 1,210 feet, at 1,450 feet and 1,480 feet, the water at last being too heavy to continue operations.

Well No. 31. Well No. 31 is one mile south of the last and on the bank of the York river at the mouth of the same small brook as the last. The elevation is 164 feet, and the boring was commenced on April 4th, 1898, and continued till April 30th 1899, to a depth of 2,815 feet. The contact with the limestone was found at 2,450 feet, and there was a small showing of oil at 1,700 feet. The well was reported as giving

about one barrel of oil per day for a short time, and the total output is given at about 23 barrels.

Well No. 32 is the most easterly of this group. It is situated near the bank of the York river at an elevation of 200 feet. Boring began in January, 1899 and the hole was carried down in sandstone and shale to a depth of 1,825 feet to the limestone in which the boring continued to a total depth of 1925 feet. on June 13th. A little gas and oil was found at the contact, and it is reported to have yielded about ten gallons of oil per day for a time. In July, 1902, it pumped from 5 to 6 gallons. a day, but irregularly. The pumping log of this well gives a total yield to Aug. 9th, 1902, of 1,745 gallons. Well No. 32.

Well No. 33 is situated 2½ miles further up the river than the last and on the bank of the stream. The elevation is 200 feet. Work began on May 8th, 1899, and ended on Aug. 26th, 1901. No oil was found in this hole and the limestone was not reached, the rock being sandstone and shale throughout. The well is now discharging salt water, which with gas was struck at several points, and the total depth reached was 2,607 feet. Well No. 33.

Well No. 34 is located near the centre of the second group of wells, at an elevation of 310 feet. It was commenced on June 25th, 1900, and ended Oct. 6th, at a depth of 1,677 feet. No limestone was reached. A small quantity of oil and salt water was struck at 1,600 ft. It pumped half a barrel a day for some time, the record of the pumping log giving a total yield to May 24th, 1902, of 1,744 gallons. Since that date to Aug. 9th, the output has been only salt water. Well No. 34.

Well No. 35 is about 1¼ miles north-west of the last. The elevation is 360 feet, and it was commenced in May, 1901, and continued to a depth of 1,810 feet, on the 17th August. Limestone was struck at 1,800 feet, but no show of oil was found. The limestone was so hard that the breaking of the tools prevented further work. Well No. 35.

Well No. 36 is the most northerly of the wells in group one near Gaspé Basin. It is situated near the crest of the Tar Point anticline at an elevation of 804 feet, and is probably about one-eighth of a mile north of the supposed axis. Work began on July 9th, 1901, and continued till Dec. 4th, to a depth of 1,950 feet. The probable contact of the limestone was reached between 1,780 and 1,825 feet, as some sandy layers were intersitatified in this portion. No oil was found in the boring, but salt water was struck at 1,065 feet, and again at 1,225 feet. The limestone in the lower portion also appeared to have interstratified sandy layers. Well No. 36.

Well No. 40.

Well No. 40 is the most westerly hole bored. It is located on Fall brook, a branch of the York from the north, in the west part of block 38. Its elevation is 827 feet, and it is supposed to be a short distance south of the St. Peter anticline. The log of this well showed sandstones all the way to a depth of 2,305 feet.

Well No. 39 not bored.

Well No. 39 is located on the line of the Tar Point anticline, north of the wells of group one, but though the rig is in place it has not yet been bored, since the results of the surrounding wells were so unsatisfactory as, in the opinion of the resident engineer, not to warrant the expense.

Wells of the Canada Petroleum Co.

In addition to the wells of the Petroleum Oil Trust just described, a number of other wells was bored by the Canada Petroleum Co., in the area included in groups one and two. Of these the four located in group one have already been noticed in preceding pages. Of the second group seven were put down on the north side of the York river, including Nos. 1, 2, 4, 5, 6, 8 and 11, while a 12th well was located on the bank of the York at the mouth of a small brook on the north side about five miles further up the river. With the exception of the last these are all located on what is known as block 40.

Well, No. 1 and 2.

Of these wells, No. 1 was started on July 6, 1899, and finished on Sept. 22nd, at a depth of 1,582 feet. The elevation was 270 feet. The boring was entirely in sandstone and the limestone was not reached. Oil and gas were struck at 1,550 feet, and the well was fitted for pumping and was pumped in 1901 from June 25th to Sept. 21st, in all 39 days, yielding in this time 949 gallons. In 1902 it was pumped from May 22nd to July 24th, in all 25 days, the yield being in all only 75 gallons, or an average of 3 galls. per day for the latter period. In August the well was flowing salt water only. The total recorded oil from this well was 1,024 galls.

Well No. 2 is situated about 100 yards south of the last. The elevation is 230 feet. It was commenced on August 5th, 1901, and finished on October 13th at a depth of 1,591 feet. Oil and gas were found in small quantities at 1,570 feet. The pumping log of this well gives an output of only three gallons.

Wells Nos. 4, 5 and 6.

Well No. 4 was commenced on August 15th and finished on November 11th, 1901. The elevation was 276 feet, at a point one-quarter of a mile east of last. The depth of the boring is uncertain but from 2,100 to 2,200 feet, at which point the limestone was reported. No oil found but salt water was met with. The boring was in sandstone and shale all the way.

Well No. 5 is about 300 yards south-west of the last. The elevation is 200 feet. It reached a depth of 2,200 feet and shows of oil were found at 1,349 and at 2,140 feet. About three barrels are reported as taken out, probably by bailing, as no pumping log exists, and the well was abandoned. The last show of oil is apparently near the contact of the limestone with the sandstone.

Well No. 6 is about 150 yards west of No. 2. The elevation is 246 feet, and it reached a depth of 2,360 feet to the limestone. A very small trace of oil was reported at 2,340 feet, which was of no importance, and the well was abandoned, no oil being taken out.

Wells Nos. 8 11 and 12.

Well No. 8 is on the bank of a small stream about 600 yards south-west of the last. It reached a depth of 2,394 feet, and the limestone was struck at 2,340 feet, where a small trace of oil was found. The well was shot without beneficial results and then abandoned. The elevation of the site is 210 feet. Salt water was struck in the upper part but cased off.

Well No. 11 was sunk on the bank of the York river on the line between blocks 40 and 41. The elevation is 150 feet and the depth reached was 1,924 feet, the limestone being struck at 1,900 feet. Found salt water with a little oil at 1,490 feet in the sandstone, but the oil was of no importance, and the well was abandoned.

Well No. 12 is situated on the bank of the York river at the mouth of a small brook on block 39. The depth reached is given as 1,500 feet without any trace of oil being found. A band of black shale was passed through at 280 feet. This location is about midway between the Point St. Peter and Mal bay anticlines.

International Cos. well.

In addition to the records of wells already given it may be said that the International Company bored a well in block 41, on a small brook which flows into the York river near the location of No. 6 of the Petroleum Oil Trust. The site was evidently chosen from the fact that several oil-springs occur in the vicinity, one of which is of quite large size. A line of fault crosses the area a short distance south-west of the location and a high ridge of sandstone rises to the north-east, while the limestone is brought up by the fault just to the south-west. The dip of the rocks is to the south-west at an angle of 16 degrees. The boring was carried to a depth of 1,700 feet in sandstone throughout, as would naturally be expected from the position of the rocks in the area, and no trace of oil was found. The limestone to the south is bituminous, and the oil-springs evidently proceed from the line of fault, there being three of these springs on this line in a distance of about half a mile along its course.

The pumping logs.

The study of the pumping logs shows certain features relating to the occurrence of oil in some of the wells which is of considerable importance. After the wells have been standing for some days or months there is manifestly an accumulation of oil in some of them which has gathered by slow percolation from the surrounding rocks, probably along fissures. Thus, when pumping operations were commenced in 1901 on some of these, the output for several days was fairly large, but in a short time it fell off to a few gallons or even quarts, and in some cases entirely ceased.

The first date of pumping appears to be March 9th, 1902. Thus in well No. 31, which is in the group on block 40, the first day's yield is given as 260 gallons, on March 15th the same amount, but on the 22nd the output was only 80 gallons, on the 27th only 40 gallons, on the 28th only 20 gallons, and on the 30th 18 gallons. On April 3rd, after an interval of three days, the outflow was 38 gallons, then daily for three days it pumped 15 gallons. After six days rest it amounted to 37½ gallons on April 19th. On May 6th, after sixteen days rest, the outflow was 87 gallons, or an average of only 5½ gallons per day. This yield gradually diminished, till on July 11th, when the pumping ceased, it was only two gallons, after an interval of 16 days rest. The total amount of oil by log from this well was 1,055 gallons, or a little over 20 barrels from 27 days pumping.

In some of the wells the pumping record shows a considerable irregularity. Thus in well No. 34, the yield on March 16th, the first date of pumping, was only 10 gallons. On the 23rd, after an interval of six days, it was 40 gallons. On May 1st. it was also 40 gallons. From this date it was pumped regularly till the following September, the yield varying from five gallons per day to 30 gallons, or a daily average for pumping days of about 10 gallons per day, or, for the whole period, of 5½ gallons. In 1902, for the three days in April from the 22nd to 24th, the yield was 247 gallons. Then water only for 14 days, and for seven days in May, from the 9th to 24th, it varied from a quarter gallon to one gallon, after which the yield was water only to August 9th, at the time of our visit. The total yield from this well per log was 1,744 gallons for the two seasons' pumping.

Logs of wells

Well No. 32 began pumping on March 22nd, 1901, and was pumped until September 21st. of that year. In 1902, it was pumped from April 26th to August 9th, the day of our visit, in all 188 days. The total yield was 1,745 gallons, or an average of about 9½ gallons per day. In the latter year the yield varied greatly, ranging from one gallon per day upward, and for the last month averaged about four gallons per day.

Well No. 19 was pumped from May 22nd, 1901, to September 21st, and in 1902 from April 22nd to August 9th, in all 163 days. The total yield is given as 850 gallons, or an average per day of about four gallons. From May 1st, 1902, the yield was for the most part about one gallon daily, occasionally reaching three gallons.

Well No. 17 was pumped from April 24th, 1901, till August 22nd. The total yield was 126 gallons for 16 days' pumping during this time, or an average daily flow of about one gallon.

Well No. 15 was pumped, in 1901, from May 25th to August 5th, with a total yield of 231 gallons, or a daily average of about three gallons.

Well No. 11 was pumped for four days only. On May 25th, 1901, it gave four gallons, on June 4th, 50 gallons, on June 28th, 17 gallons, and on July 6th only four gallons, in all 72 gallons, or less than two gallons per day for the whole time.

Well No. 22 was pumped for three days only in 1901. On June 1st. it gave 600 gallons, on June 3rd, 200 gallons, and on July 26th, only 10 gallons.

Well No. 12 was also pumped for three days only. In 1901, June 26th, 30 gallons; July 3rd, it gave one gallon; on July 26th, 55 gallons; in all 86 gallons.

Well No. 16 gave on June 10th, 1901, 150 gallons. Nothing further recorded, output probably obtained by bailing.

Well No. 13 gave on June 12th, 40 gallons, and on July 6th, only one gallon.

Well No. 10, on June 5th, gave 125 gallons, on the 24th, eight gallons, and on the 27th, only one gallon.

Well No. 14 gave on June 25th 16 gallons, on June 26th only one gallon, and one gallon also on July 6th.

Well No. 27 was pumped, in 1901, from April 5th till August 15th. The yield for this period was 385 gallons, or an average of rather more than 2½ gallons per day. In 1902 it was pumped from June 18th till August 9th, with an output of 192 gallons, the daily yield steadily declining till August, it averaged about one gallon to one-half gallon per day. The total yield of this well was 577 gallons.

Well No. 20 was pumped from March 28th, 1901, till September 21st, with a yield of 1,042 gallons. In 1902 it was pumped from April 2nd till August 9th, with a yield of 708 gallons. In all a total of 1,750

gallons. The daily average in 1902 was about two to three gallons for the greater part of the time. An interesting point in connection with this was the yield for April 21st, which was only two gallons, while on the 22nd it is given as 280 gallons, but this on the 28th had fallen to seven gallons.

Total amount of oil pumped, 1901-1902.

The total amount of oil as per these pumping logs taken out in 1901 and 1902 amounts therefore to 9,384 gallons, or allowing 45 gallons to the barrel, about 208 barrels. In addition to this the Canada Petroleum Co. give an output of 1,227 gallons, or about 27 barrels.

This is exclusive of the different amounts claimed to have been lost by fire and otherwise during the period of borings, of which no reliable estimate can be obtained.

Occurrence of oil.

From a careful consideration of all the data at present to hand regarding this field as a producer of oil in economic quantities, it must be said that the outlook can scarcely be regarded as favourable. There are no well-defined oil-sands, such as are recognized in the true oil territory, and where oil has been obtained in reported large quantities it would seem to occur in isolated pockets only, since the continuation of the borings to a greater depth has given no favourable results. That oil in small quantities exists in different portions of the sandy strata, and occasionally also in the limestone is evident from the records, but so far it is plain that nothing which can be regarded as of economic value has been found.

Unfavourable conditions for oil.

There are practically no data obtainable by which wells may be located with even a fair prospect of finding oil in paying quantities. The anticlinal theory which is applicable to the western oil fields as being favourable to the occurrence of oil, is not supported by the results obtained in this area, and the presence of numerous faults, with steeply inclined strata, and the abundance of salt-water which is encountered in most of the borings already made, are all against its successful exploitation. At the present time the location of bore-holes is entirely a matter of chance; and though holes have been sunk to a depth of over 3,500 feet such deep borings have only been made at enormous expenditure, and in every case without any satisfactory results. The theory that the oil occurs at the contact between the sandstone and the limestone must also be abandoned. The supposition that the presence of oil-springs at different points is a favourable indication of large underlying deposits of oil has been clearly disproved, and since these usually occur along or near lines of fault must be considered as adverse to that hypothesis. The expenditure of such large sums of money as have been made during the last fourteen years, and the

Oil springs.

absolute lack of results in finding oil in paying quantity, may well be taken as conclusive that no satisfactory results will be obtained from such further expenditure in this direction.

The Albert Shale Deposits of Albert and Westmorland Counties, N.B.

R. W. Ells, LL.D., F.R.S.C.

The following report on certain economic aspects of the Albert shale deposits of Albert and Westmorland counties, New Brunswick, may be regarded as, in most respects, supplementary to the general report on these rocks, published in 1876-77, in the annual volume of the Geological Survey by Dr. L. W. Bailey and the writer. At that time a somewhat exhaustive examination of these shales and of the associated rocks was carried out throughout their whole extent in the two counties mentioned, more particularly with reference to the presence of the valuable mineral albertite, which had for some years been largely and profitably mined at the 'Albert mines.' Former reports.

In the course of that examination the presence of heavy beds of what is usually known as 'oil-shale,' now styled by some persons 'cannelite,' was observed; and while these heavy bands were not found to bear any close association with the deposits of albertite, their undoubted value as a possible source of supply for oil by distillation was clearly recognized.

The mode of occurrence of these heavy oil-shales is quite distinct from that of the albertite. In the case of the latter the mineral occurs in the form of true veins, which sometimes follow the lines of stratification of the inclosing shales, but which also often traverse them at well defined angles. This aspect of the question has so often been discussed by various writers that further enlargement on the subject is unnecessary, and the once stated opinion that the albertite occurred as a true bed, similar in this respect to bituminous coal, may now be altogether laid aside. Occurrence of Albertite.

On the other hand the massive 'oil-shales' occur as true interstratified beds in the bituminous shale series. Character of oil-shales.

As to the geological position of the shales as a whole it may be remarked that somewhat diverse opinions have been held from time to time by different observers. Thus in the early days of their investigation it was supposed that they represented an integral portion of the

Lower Carboniferous formation. This conclusion was reached from the presence in certain bands of the shale of remains of fossil fishes and plants which were then supposed to have a Lower Carboniferous aspect and to definitely fix their horizon. The investigations made in 1876 showed that however true this might be, the mass of the shales themselves occupied a position entirely unconformable to the true Lower Carboniferous sediments, associated with limestones and gypsum, and which are well defined throughout the area, and that with good reason they should therefore stratigraphically be assigned to a lower horizon or regarded as of Devonian age. It may be added that this view as to their position is now generally accepted by those most familiar with their study in the field.

Horizon of Albert shales.

Extent of the deposit.

As for the extent of the Albert shale formation it may be said that it has been traced for a distance of over thirty miles from east to west. The shales are not, however, continuously exposed throughout this whole distance, since they are sometimes covered over by overlying sediments, either of Lower Carboniferous or Millstone-grit age. In Albert county they occupy a position for a considerable portion of their area along the north flank of the range of hills known as the Caledonia mountains, the rocks of which consist of granites and other intrusives along with gneiss, schists of various kinds, hard slates, &c., which are regarded as of Pre-Cambrian age. The course of this range is north-east and south-west. East of the Albert mines the crystalline rocks are not seen, except in a small outcrop near Calhoun's mill on the Memramcook river, a few miles north of Memramcook village, on the Intercolonial railway. The shale deposits extend onward across the Petitcodiac and Memramcook rivers, showing in the banks of both streams and at different points over the intermediate area, as at Beliveau, Taylorville and along the roads between Dorchester and Memramcook.

Areas in Albert Co.

In the Albert county area the best exposures are seen at the Albert mines, four miles west of the Petitcodiac river. In the intermediate space they are, however, largely concealed by the overlying Lower Carboniferous formation which includes the gypsum deposits of the Hillsborough Plaster Co. Further west they are well seen at Baltimore, six to eight miles distant from the Albert mines, outcropping along the courses of the several branches of Turtle creek and in numerous outcrops on the hillsides. Though they have not been traced continuously between these two places owing to the fact that they are sometimes concealed by red and gray marls of the overlying formations, it is regarded as very probable that they form a continuous belt for the entire distance.

Albert mines and Baltimore.

West of the Baltimore areas the shale belt is continuous for a further distance of some four miles to the south branch of Prosser brook, where it terminates against a spur of the old mountain rocks. The shales, however, again reappear to the west from beneath the Lower Carboniferous sediments at Pleasant valley and again at Mapleton, the latter place about three and a half miles east of Elgin Corner, where they form a band about two miles in length. West of Elgin they are also exposed along a branch of Pollet river and form a narrow band along the course of the stream. This outcrop practically marks the western limit of the shales in Albert county. Elgin and Mapleton.

The exposed width of these shales is nowhere very great, and in Albert county seldom exceeds half a mile, but in Westmorland this breadth is in places somewhat greater. The rocks of the area are frequently much disturbed, being affected by numerous faults and often inclined at high angles. At the Albert mines and also at Beliveau and Taylorville, this feature is common, and several well-defined anticlinals are visible at these places. In the Baltimore area the shales are more regular, with a prevailing dip to the north at angles of 15 to 25 degrees. Faulted character.

In certain areas the shales are underlaid by a hard green conglomerate which is made up of the debris of the mountain rocks. This feature is well seen on Pecks' creek, west of the Albert mines, as well as at Beliveau, at Mapleton and at the locality west of Elgin Corner. Conglomerates.

The thickness of the shale formation has been estimated at about 1,000 feet or possibly something more, since owing to their folded and faulted character the exact determination of their volume is rendered very difficult. In their physical characters they vary somewhat in different localities. Some of the beds are comparatively sandy, constituting in places a bituminous sandstone, while other portions are quite thin and papery. Occasionally thin bands of a hard dolomitic-looking limestone form interstratified layers, but the bulk of these is small. As a rule the shales and sandy layers are bituminous throughout the formation, but certain portions have this feature much more largely developed than others. Thickness and character of shale.

Small veins of the black shining mineral albertite are quite abundant at several localities. As a rule these are too small to be mined profitably, and, with the exception of the large vein which was worked so successfully for many years at the old Albert mine, no deposits of this mineral have elsewhere as yet been found in paying quantity. A peculiar feature of this mineral is its occasional association with both Occurrence of albertite.

the underlying and overlying rocks. Thus at several points it is known to occur in the old rocks of Caledonia mountain as small threads. In this case it is probably due to infiltration from the overlying shales; while in the upper series of Lower Carboniferous limestones, gypsum, and conglomerates it is occasionally observed in small irregular veins or stringers, and even in the still higher sandstones of Millstone-grit age it is sometimes found in veins of considerable size, so much so that, at what is known as the East Albert mine, attempts have been made to mine the deposit of albertite. In such positions the mineral may be regarded as a distillate, newer than all the rocks in which it occurs.

The East Albert mine.

The old Albert mine.

At the old Albert mine the deposit which was evidently of the nature of a true fissure vein, was worked downward to a depth of nearly 1,400 feet from the surface. In the lower levels the vein matter frequently occurred as a cemented mass of shale and albertite, the substance being too impure for shipment, and large quantities of this material were thrown out in the dumps where it can be readily seen. In the case of the albertite itself also, owing to the great purity which was at that time required for shipment, quantities of the mineral were thrown aside with the waste. This albertite can also be everywhere observed in the mass of the dump and around its sides where it has been washed out, and many of these pieces are of good size and quite free from any impurity. On the whole it may be said that many tons of pure albertite have been thus thrown away.

Other veins untested.

It was supposed at the time mining operations were suspended at this mine that the mineral in paying quantities was practically exhausted. It does not by any means follow, however, that this was the actual state of the case. Several small veins have long been known to exist which have as yet been practically unopened, and their actual value as yet not fully ascertained, and one of these, situated on the north side of an anticlinal near the main road through the old village, shows at the surface an exposed breadth of at least two feet This vein, which appears to be a branch of the main vein which was worked for so many years, is certainly worthy of being tested to prove if it does not extend, and even increase in size at greater depths, a possibility which, from the irregular character of the main vein, is likely to occur.

The oil shale bands.

The 'oil-shale bands' to which this report is especially supposed to relate, occur in different parts of the shale body. They consist of thick seams of a dense, usually black and massive rock, radically differing from the ordinary bituminous shales, though they have usually

been regarded and described under that head. They form regular beds, extending over long distances, and are thus entirely unlike albertite in that the vein structure of that mineral is entirely absent.

Their oil contents.

These beds of 'oil-shale' range in thickness at the Albert mines from three to nearly or quite six feet, and at least five of these bands or beds have been recognized at this place. The rock is very compact, breaking with a roughly conchoidal fracture, with a veined or woody aspect on weathered surfaces, apparently entirely free from grit of any kind, since it can be readily cut with a knife without appreciably dulling the edge, is very rich in oil, and certain portions readily ignite in the flame of an ordinary match. By analysis these dense 'oil-shales' are reported to yield, in portions at least, and the rock appears to be quite uniform throughout the largest beds, from 60 to 65 gallons of oil per ton. Along the course of Frederick brook, which traverses the area to the north of the main line of old workings, these strata of 'oil-shales' show in successive bands, separated by other shales, often brown in colour and sometimes highly bituminous, though the percentage of oil in these has as yet not been fully determined. It is probable however that a large portion of these intermediate shales will yield not far from 30 gallons of oil per ton.

Thickness of bands.

These black 'oil-shales' are also well developed at Baltimore and at Taylorville. At the former locality, four or possibly five of the bands occur, varying from three to six feet in thickness; and as far back as 1864, works for the extraction of the oil by distillation were erected and the industry carried on for several years. The discovery of the oils of the west, however rendered crude oil so cheap that in face of a duty of ten cents per gallon on the output, the greater part of which went to the United States for refining, the industry was obliged to close down. The rich bands at Taylorville were also quarried to some extent for the same purpose.

Baltimore and Turtle creek.

The black bands are well exposed on all the branches of Turtle creek in the Baltimore area and they have been opened by several drifts on the hill-sides. The thickness of the several bands is thus well established in this district. On the west branch of Turtle creek, beyond the Stewart farm the colour of the oil-bands becomes grayer but the mass of the rock is filled with blackish streaks, and the per centage of oil from these beds, of which two are known to occur, is apparently greater than in the black bands, reaching by analysis as much as 80 to 85 gallons per ton. The thickness of these two gray 'oil-shales' on the west branch is stated by Mr. William Hall, formerly manager of the Spring Hill coal-mines, to be 20 and 21 feet. They

have been opened to some extent and some tons extracted. The rock kindles readily on application of a lighted match to thin pieces.

Bands at Taylorville.

The number of 'oil-shale' bands at Taylorville was not ascertained, though there are several in the area. In character they are like the bands at the Albert mines, and the quarry from which they were mined is in a field near the road crossing from Upper Dorchester and about one mile from the Memramcook river.

The quantity of material in these rich shale bands is therefore practically unlimited, and has been estimated by several mining engineers who have examined the property at as much as 270,000,000 tons.

Extent of the Albert shale deposit.

How far these Albert shales extend to the northward beneath the Lower Carboniferous and Millstone-grit sediments is at present uncertain. It is not supposed, however, that they underlie the whole Carboniferous basin, since east of the Petitcodiac and Memramcook rivers the structure is apparently basin shaped. They may, however, be repeated at several intervals. The most northerly recognized outcrop yet seen is on the north side of Indian or Lutz mountain, where on the road leading to the McLaughlin road they are exposed for some distance and apparently extend down the slope of the hill overlooking the valley of the Cocagne river. The shales of this locality resemble very closely those of Albert county and are probably of the same horizon, though they are much less rich in bituminous matter where exposed.

Lutz mountain band.

From Dr. Oliphant's paper on the oil industry taken from the Annual Volume U.S. Geological Survey, Vol. XX., 1898-99, the following figures are extracted :—

Statistics.

Quantity and value of the oil-shale produced in Great Britain, mostly in Scotland.

1890	2,212,250	tons.	£608,369
1891	2,361,119	"	707,177
1892	2,089,937	"	522,484
1893	1,956,520	"	489,130
1894	1,986,385	"	496,506
1895	2,246,865	"	561,716
1896	2,419,525	"	604,881
1897	2,223,754	"	555,936

Remarks.

A ton of bituminous shale yields very nearly an American barrel of petroleum distillate, and its cost is very nearly that of a barrel of crude laid down in Scotland.

A hundred gallons of crude shale oil obtained by distillation of the bituminous rock yields about 30 gallons of fair illuminating oil, 16 gallons heavy oil, 14 gallons paraffine scale, 8 gallons lighter oils, and 5 gallons of petroleum spirits, while the residue is tar and coke, suitable for fuel only. Each ton of shale yields also about 50 lbs. of sulphate of ammonia. Analysis of crude shale oil.

Profits.

Broxburn Co., 1898, 6 per cent on preference stock and 8½ per cent on common. Profits of manufacturer in Scotland.

Oakbank showed a profit of $55,000 and a 5 per cent dividend declared.

Pumpherston, an apparent profit of $105,000, dividend 6 per cent.

Loss.

Young's Co., deficit of $40,000.

Holmes Co., shrinkage of $30,000.

Clippens Co., loss of $70,000. Towards end of 1898, all stocks showed great improvement.

Report on the Geology of Prince Edward Island with reference to proposed Borings for Coal.

Dr. R. W. Ells.

In the year 1883, several weeks were spent by the writer in a brief study of the geological formations found on Prince Edward island and a short report thereon was given in the Geological Survey Report for the years 1882, 1883–84, more especially as relating to the western and southern portions of the island. Sufficient data were however at that time obtained to warrant the conclusion that the rocks found in the eastern portion were practically similar in age at least to those which were more carefully examined. Work of 1883.

In that report the opinion was expressed that the views put forth by Sir William Dawson in his report on the island in 1870, that the greater part of the red sandstones and shales of which the island rocks are largely composed, were of Triassic age, would need to be somewhat modified, and that, in so far as then examined, these rocks more properly belonged to the Upper Carboniferous series, or possibly to the Sir Wm. Dawson's report, 1870.

Permian. The term Permo-Carboniferous was therefore chosen as best meeting the nomenclature of the question.

Change of view.

The areas assigned by Sir William Dawson, in his report, to the Upper Carboniferous formation were confined to a strip on the western shore from West Point to North Cape, and to certain areas east of Charlottetown and near the entrance to Charlottetown harbour, of which, however, he did not consider the age as actually determined. The detailed examination of the island in 1883, however, showed that such a separation was not possible, but that so great was the similarity in the rock formations over the greater part of the island, the whole or at least the greater portion should be included under the same head

Work of Francis Bain.

Subsequently Mr. Francis Bain, working independently, and largely in connection with the plant remains which are found at many points throughout the whole province, came to a similar conclusion as to the Upper Carboniferous age of the greater portion of the island rocks from the fossil evidence. These conclusions were presented in a paper read before the Royal Society of Canada in 1885 by Sir William Dawson, and with his comments thereon were published in the *Canadian Record of Science*, Montreal, vol. I., for that year. A previous paper by Mr. Bain relative to some fossils which he had found there was also printed in the *Canadian Naturalist* for 1881, in which the Upper Carboniferous character of the plant remains was indicated. The Triassic rocks were at that time regarded as confined to a limited area in the vicinity of New London, on the north side of the island, and the evidence upon which this separation was based was the finding some years before of the fossil *Bathygnathus borealis* which was then regarded as of Triassic age. With the exception of this fossil from the New London area, it may be said that all the evidence points to the opinion that the red sandstones and shales of which the island is largely composed may all be assigned to the Carboniferous horizon, or, as some geologists prefer to call them, Permian.

Supposed Triassic area.

Importance of establishing age of rocks.

The establishing of the age of these rocks as Upper Carboniferous is important in view of the proposed explorations for coal by boring. Though there are nowhere visible on the island, any rock formations which can be assigned to the underlying series of the productive coal-measures, such as occur in the province of Nova Scotia, the fact that their age is Upper Carboniferous instead of the higher or Triassic formation, shows that the probable depth at which coal-measures may be reached, if indeed such rocks underlie the island anywhere, is much less than was originally supposed.

The key to the problem regarding the occurrence of underlying deposits of coal on the island itself, cannot be ascertained from the study of the rock formations there exposed. There is in the province no actual data on which to base the occurrence of the lower or productive measures. In order to arrive, if possible, at some definite conclusion on this subject, some time was spent in an examination of the formations along the adjacent shores of New Brunswick and Nova Scotia, where rocks similar to those which occur over a large part of Prince Edward island, also occur.

Comparison with New Brunswick and Nova Scotia rocks.

In New Brunswick a narrow margin of the red sandstones, conglomerates and associated shales of the upper series is found at several points along the shores of the Gulf of St. Lawrence, as far north as Shippegan island. They are also well seen in the Tormentine peninsula where they pass downward into underlying gray sandstones, which here are supposed to represent the lowest portion of the Upper Carboniferous in this direction.

Cape Tormentine.

Near Shediac and along the east coast of New Brunswick, these newer rocks rest upon gray sandstones and conglomerates which have been regarded as of Millstone-grit age, and the productive coal-measures have not as yet been recognized in this part of the province. While the gray beds of the two somewhat widely separated divisions of the Carboniferous rocks present certain points of similarity, there are some features which render their separation possible. The sandstones of the upper series can be generally distinguished by being much softer and less coherent in character than the gray grits and conglomerates of the Millstone-grit series.

Shediac and vicinity.

South of Baie Verte, this difference in character can be readily seen on the road leading across to Aulac. Thus, at the latter place, what is known as the Aulac ridge rises near Aulac station on the Intercolonial railway, and extends in a north-east direction, in the direction of Pointe de Bute and Tidnish. The rocks of this ridge are gray grits and quartz-pebble conglomerates, and have a distinct anticlinal structure.

Baie Verte and Aulac.

About seven miles south of Baie Verte the Millstone-grit outcrop terminates, but at Halls hill, which is about two miles further north, a series of gray sandstones comes these rocks in, and have been cut down along the roadway. These belong to the newer series, and are soon overlaid by the soft red beds which are so conspicuous along the shores about Baie Verte, and thence east to Tidnish and on to Pugwash in Nova Scotia. In these red beds are bands of conglomerates in which the pebbles are

Upper conglomerate rests on Millstone-grit.

largely made up of bright red shale, and thin bands of impure red limestone also occur at several points. The series as a whole is quite distinct from anything seen in the Millstone-grit formation, and precisely resembles the rocks seen along portions of the shore of Prince Edward island, from Cape Egmont to Wood islands, as well as at many other points in that province. In New Brunswick they are also well exposed at Cape Tormentine, and along the shores of that peninsula at many places, while at Bayfield corner, and around Port Elgin they are underlaid by the grayer members of the upper series, which also show on the road between Shediac and Pointe du Chêne.

The formation in northern Nova Scotia. These soft red rocks with occasional gray sandstones also appear along the north side of Nova Scotia in the counties of Cumberland, Colchester and Pictou. Here for the most part they overlie directly, in so far as yet known, rocks of Lower Carboniferous age without the interposition of the Millstone-grit or productive coal-measures. This contact appears to be of the nature of an overlap since there is no indication of faults between them. It is probable, therefore, that in this northern portion the true coal measures have never been deposited along this side of Northumberland strait.

Pictou and Merigomish. Further east the rocks of the newer series are exposed along the south side of Northumberland strait to a point several miles east of Merigomish island, or about twenty miles east of Pictou harbour. At this place they rest upon sediments of Silurian and Cambro-Silurian age with which are associated granites and other igneous rocks. East of this the red rocks of the upper series are not exposed, either along the shores of Nova Scotia proper or on the Island of Cape Breton. There would therefore appear to be a gap of considerable extent in the sequence of the geological formations in this part of the province.

Anticlinal structure in P. E. I. The structure of the rocks in Prince Edward island indicates the presence of several lines of anticline which extend across Northumberland strait from New Brunswick and Nova Scotia, and traverse the island in a general north-east direction. In order to locate these as precisely as possible an examination was made of the whole shore line, since but little information regarding structure could be obtained from the few exposures seen on the surface of the island itself. In fact, owing to the presence of much false bedding, the occurrence of dips and strikes thus seen were of but little value. The coast sections, however, are fairly good, though there are occasional long stretches occupied by sands where rock outcrops cannot be observed. The general succession of beds along the greater part of the shores can, however, be fairly well ascertained.

Apparently the lowest rocks of the Island series are dark red sandstones with occasional beds of conglomerate in which the pebbles are of soft bright red shale, with irregular beds of impure limestone, generally reddish in colour, but at several points a gray limestone also occurs. Pebble conglomerates are also seen at several places, as at North cape, and on the shores of Mill river south of Alberton, the pebbles being of quartz with, occasionally, pieces of hard metamorphic rocks. On the ridge about ten miles north of Wood island, and on the road to Cardigan, a deposit of well rounded pebbles is seen which have evidently been derived from beds of these conglomerates in the vicinity, and traces of which can be recognized in place. Rock of lowest division.

In character most of these red rocks are very similar to the beds seen in the sections along the Wallace and Waugh rivers on the north side of the Cobequid mountains in Nova Scotia. They are sometimes interstratified with beds of grayish sandstone which are usually thin and irregular, the gray colour apparently due to the elimination of the red colouring matter through the agency of plant stems which frequently occur in these lowest beds. This charactor is well seen at St. Peter island, near the entrance to Charlottetown harbour as well as on Governor island near by. Further east similar gray irregular beds are exposed in parts of the section at Gallas point. Similar to rocks in Nova Scotia.

On the west coast the nearest approach to this feature was observed on the shore at Campbelltown, where, underlying the great series of red shales and sandstones which form the cliff between Big Mimenegash and Wolf cape, coarse reddish grits with grayish bands crop out at the base of the bluff. While these may not be quite so low in the series as some of the lowest beds of Gallas point, they apparently indicate the lowest members of the series in this direction. Campbelltown and Mimenegash.

These are overlaid by a considerable thickness, probably aggregating several thousands of feet, of soft red sandstones and shales, occasionally with bands of impure limestone, which are seen over the greater portion of the surface of the island. Much of the sandstone is a dark red or red-brown, and these pass up into red sandstones with shales which continue to the summit of the formation. Throughout this series there is no very great variety as regards the character of the rocks themselves, and all may be included in the same general group, The usual dips of the strata are to the north-west and south-east. They are usually at low angles, rarely exceeding ten degrees, and more often ranging from two to six degrees. Occasionally however this inclination is as much as fifteen to twenty degrees for short distances. These seem to indicate slight disturbances of a local nature. Character of strata.

Local fault.

Only two small breaks were noticed, of which one was on the south shore, about one mile west of Rice point, which is at the west entrance of Hillsborough bay where there is a downthrow of about thirty feet, and a slight displacement on the north side of Governor island of less than ten feet. Eruptive rocks were seen at only one place, on Hog island in Richmond bay, where a dyke of diabase cuts the soft red, sandstones and has altered these for a short distance along the line of contact.

Six anticlines in Prince Edward island rocks.

The anticlines noticed in connection with the structure of the Island rocks are apparently six in number. Of these the most northerly comes across from the New Brunswick shore in the vicinity of Richibucto head, and is not seen on the island proper as its course extends along the north-west shore a short distance out from the coast line. This may be styled the Mimenegash anticline. The rocks along this part of the coast, where observed between West cape and North point. all have a well-defined south-east dip, the strike being approximately parallel to the line of the shore, with angles ranging from two to seven degrees. On the shore near Little Mimenegash creek, a bed of gray limestone occurs, visible only at low water, which has been locally quarried to some extent both for lime-burning and for building stone, the church at Tignish being built from stone taken from this locality. These gray limestones were not seen at any point on the surface of the island.

1st anticline Mimenegash.

2nd anticline Egmont bay.

The second anticline is regarded as crossing the strait from the vicinity of Shediac point, north of Shediac bay on the New Brnnswick shore, to the inner point of Egmont bay near the mouth of Percival river. The shores for some distance on either side of this bay are low and sandy, but there are certain low dips on either side of the island in the line of its supposed direction which should indicate its position fairly well, and it should reach the north shore of the island near Cavendish inlet. This line of disturbance is styled the Egmont anticline, but it is not so well defined as several of the others. Its western prolongation in New Brunswick should connect it with the outcrop of the old rocks in Indian mountain north of Moncton. The dips along the shore at Brae head on the north side of Egmont bay are all to the north at angles of three to five degrees.

3rd anticline Summerside.

The third line of disturbance may be styled the Bedeque bay anticline. It apparently extends from a point on the north side of the Tormentine peninsula, a short distance east of Cape Bald, whence it should cross to the vicinity of Summerside and continue to the north side of the island near Cousins pond, about two miles west of Cape

Tryon. The opposing dips of this anticline, though generally low, are well defined and rarely exceed four to six degrees. On the north side of Bedeque bay the north-west dips are well seen at Fifteen point and at Cape Egmont, and the south-east dips are seen at Indian point, and at Graham and Sea-Cow heads, the inclination here ranging from two to four degrees.

4th anticline Cape Tryon.

The fourth anticline extends from the extremity of Cape Tormentine in continuation of the Aulac ridge. It apparently reaches the shore of the island between Cape Traverse and Tryon. The opposing dips are well seen on the shore near the Tormentine wharf. They are not well defined on the shore of the island, but, on the road north from Hunter river station to New Glasgow, the axis is well seen at a point about one mile north of the former place. It probably reaches the north shore in the low area about Rustico beach, but good exposures are rarely seen in this direction as much of the coast is occupied by clay and sands.

5th anticline Gallas Point.

The fifth line of disturbance is that known as the Gallas Point anticline. This is one of the best defined, along the whole shore of the island. The opposing dips are well seen on the west shore of the point approaching Pownal bay. On the north side of this anticline, the ledges seen on Governor and on St. Peter islands, show dips to the north-west, at angles of seven to ten degrees, and this dip is maintained to the vicinity of Charlottetown. On the west side of Hillsborough bay, the dips can be seen at Rice point and Holland cove, and on the east side at Keppoch and Battery point, as well as along the shores of Pownal bay. Opposite Charlottetown the strata apparently flatten out, and this place probably represents the contre of a syncline. The south-east dips of this anticline are seen at Prim point, and as far east as Pinette river, beyond which, eastward, the shores are generally low and sandy and exposures few, to the vicinity of Wood islands.

6th anticline Wood Island.

At this place the dips become reversed, and are again to the north-west and north. These continue as far east as Cape Bear, the inclination of the strata varying from ten to fifteen degrees. The axis of this anticline, which may be styled the Wood Island anticline, evidently lies a short distance seaward, and a syncline must occur between this and Pictou island, which lies ten miles south of High Bank, since on this island a well defined anticline occurs with a east and west direction.

In the eastern portion of the island, the several anticlines appear to flatten out to some extent, and cannot be so readily recognized. The shores are often composed of heavy deposits of clay, and sand and rock

exposures are not so continuous as farther to the west. The inclination of the strata where exposed, is generally somewhat less than those just recorded.

Syncline.

At Souris the dip of the strata is more northerly, the strike coinciding generally with the run of the shore, as far east as East point. The angle of dip varies from five to ten degrees. There is a syncline in this direction in which East point is situated, and the reverse southeast dip was not seen till we reached Campbell pond, where the beds have a low southerly dip of from two to four degrees. Good rock exposures are rarely seen on this part of the island, since the shores east from Rustico are usually low and frequently formed of sand dunes or of boulder clay.

Thickness of island rock.

The actual thickness of the formation, as seen on the island, is somewhat difficult to determine. According to the estimate of Mr. Francis Bain, who divided the rocks there seen, into three groups, there are in all about 3,000 feet which he arranges thus:—

Estimate by Mr. Francis Bain.

1. A lower series of gray, brown and red sandstones and shales, termed by Sir William Dawson, Permo-Carboniferous with a thickness of about 800 feet. These contain plant stems which have been determined to be of Carboniferous rather than of Triassic age.

2. A middle series, conformable to the last, or nearly so, consisting of red sandstones and shales, with calcareous sandstones, which occupies the greater part of the island, the thickness of which he estimates at 2,000 feet; and

3. Red sandstones and shales, not distinguishable from the last, seen at New London, and having an estimated thickness of 150 feet. These include the Cape Turner beds of the north shore.

Probable thickness at Charlottetown.

It is doubtful if this estimate of thickness covers all the sediments of the island, and it is highly probable that the total volume is considerably greater. Thus making due allowance for false-bedding, and the difficulty of securing correct dips, if we take the section north from the crown of the Gallas point anticline to the supposed centre of the basin at Charlottetown, and allow a dip of seven degrees only, the thickness will amount to not far from 6,500 feet, or with an average dip of only five degrees the total thickness will be not far from 4,500 feet. This last estimate is, however, probably too low.

Comparison with similar rocks in Nova Scotia.

In this connection information obtained from sections made of similar rocks along the French, John and Waugh rivers in that part of Nova Scotia between Northumberland strait and the Cobequid

mountains will be of value. Most of these sections were very carefully measured by Mr. Hugh Fletcher of the Geological Survey. The rocks in this area consist largely of red sandstones and shales with, occasionally, gray beds of sandstone, and probably carry the formation, as seen on Prince Edward island, to the bottom of the series. It may be said also that in these sections no trace of the productive coal-measures was found, the Upper Carboniferous resting upon the old mountain rocks. Work by Mr. Hugh Fletcher.

Thus, on the French river a thickness of 4,925 feet was found. In all this there was no trace of coal, further than occurred as the occasional carbonized bark of tree stems. Traces of copper were seen where the ore has been thrown down from solution through the agency of plant stems. French river section.

On Waugh river the thickness of the formation was found to be 5,045 feet of red marl and sandstones with occasional gray beds. These were underlaid by a series of red conglomerates which form the lowest portion of the formation and in some places reach a thickness of 1,500 feet. No coal was seen, but traces of copper and some small traces of albertite. Waugh river section.

On River John the section in similar rocks gave a thickness for the formation of 8,107 feet. No coal was seen, but the usual occurrence of copper with traces of albertite was observed. River John section.

A section measured along the shore from Cape John to Toney river in similar red marls and sandstones to those of the island gave a thickness of 4,622 feet. Occasional gray beds were found. Cape John to Toney river.

It is evident, therefore, that in any attempt to reach a formation below the Upper Carboniferous great care must be exercised as to location for boring operations. It may be assumed that any depth beyond 2,500 feet will be practically outside the limit of successful operations, even should coal be found unless in very large quantity. The proposed locations must therefore be selected along those lines on which the lowest rocks of the series are exposed. Conditions for proposed boring.

As the axes of the anticlines apparently dip somewhat towards the north and east, it would appear, in so far our examinations have extended, that the most suitable points for trial will be, on the north-west side at Campbelltown or Mimenegash, on the south-west of Summerside, and on the south and east at Gallas point and Wood islands. Location for bore-hole.

Coal in New Brunswick.

Yet with this knowledge of locations, the probability or possibility of success as regards finding coal in workable quantity by any boring operations must still be regarded as very doubtful. Thus along the western portion of the island the only seams likely to be encountered will be those known to occur in that part of New Brunswick adjacent. As has already been stated no defined horizon of the productive coal-measures has yet been found in that direction, the thin seams known to occur at Coal branch, of a thickness of twelve to eighteen inches, belonging to the Millstone-grit formation, to which horizon also must be assigned the still thinner seam which has been found on the lower part of the Cocagne river.

Coal branch.

Tormentine peninsula.

Further east on the Cobourg road near the road from Sackville to Bristol, about ten miles south of the shore in Tormentine peninsula a small seam of four inches occurs in the Upper Carboniferous rocks, and a like seam of from two to four inches is seen near Dupuis Corner, a few miles west of Cape Bald. These are of no value from the economic standpoint.

Big Caribou island, N.S.

In Nova Scotia along the north shore in similar rocks, a small seam occurs at several places. Thus in the boring on Big Caribou island, west of Pictou, a seam of seven inches of coal was reported, and also near Toney river, some miles further west. On the shore opposite Pictou, at Abercrombie point, a seam of fifteen inches occurs, and this outcrops at several points in the area between the East and Middle rivers near their entrance into Pictou harbour. A band of oil-shale also is found associated with the coal. Further east, on the north-west end of Merigomish island a seam eighteen inches thick shows on the beach. These seams east of Pictou apparently occur low down in the Upper Carboniferous formation.

Pictou and Merigonish.

Port Hood and Mabou.

As regards the extension westward of the seams which are found on the west side of Cape Breton Island at Port Hood, and in the Mabou district, it would appear that these are cut off seaward a short distance from the shore, since Lower Carboniferous sediments are seen on the islands off the former place, and the productive measures are probably affected by faults which would render their continuation to the island very doubtful.

Possibility of finding coal by boring.

The occurrence of many faults in the Pictou coal basin and the fact that, east of New Glasgow, the Upper Carboniferous rests directly upon the Millstone-grit where the former is developed, renders it extremely improbable that the thick seams of the Pictou basin extend beneath the rocks of Prince Edward island, so that any borings on

the south side of the island would penetrate only the thin seams of the upper formation already described as occurring along the north shore of Nova Scotia. There is a possibility of some one of these being struck in the borings at Wood islands or Gallas point, provided such seams as seen in Nova Scotia are continuous to any distance. The probability however is that such seams have merely a local development.

While therefore the outlook for finding coal in large quantity by boring, either in the Upper Carboniferous formation of Prince Edward Island, or in any formation underlying, is not very encouraging, it may be stated that the points suggested at which such trials should be made, will, if the borings are properly conducted, furnish much valuable information as to the actual sequence of formations, and there is always the possibility that other conditions than are warranted by the surface indications may be disclosed. Such possibilities can only be ascertained by a judicious expenditure of money, but in such expenditure, unless a proper supervision of the borings from day to day is maintained, and the log is properly kept, much of the beneficial results will be entirely lost. Prospect unfavourable.

THE CARBONIFEROUS ROCKS OF CHIGNECTO BAY.

Professor H. S. Poole.

I beg to report that in accordance with instructions received from the Acting-Director of the Geological Survey, I examined in more detail than was possible last year, the several series of exposures about the head of the Bay of Fundy that supply connecting links between the wide expanse of Carboniferous gray beds which extend in an unbroken series from the Baie des Chaleurs to Sackville in New Brunswick and the measures of Nova Scotia, typified by the Joggins section in which thick workable beds of bituminous coal occur. The former series, in so far as yet known, do not contain similar deposits of corresponding value. Work by Mr H. S. Poole.

I had also an opportunity of discussing on the spot some of the important structural features with both Mr. H. Fletcher and Dr. R. W. Ells of the Survey staff. Mr. Fletcher is thoroughly conversant with the range of the Carboniferous over all of Nova Scotia, but hitherto was unfamiliar with the rocks of New Brunswick; and Dr. Ells had been engaged in the study of these rocks in the last named province in 1881–84.

Spicers cove rocks.

On July 21, with Mr. Fletcher I went to Sand River, N.S., and thence to Spicer's cove on the Bay shore, a region where Sir J. W. Dawson had assumed that Millstone-grit beds were brought to the surface by faulting parallel to the Cobequid range. This assumption, it is said, was not based on personal observation, but on inspection of transmitted hand specimens, and the late survey has failed to confirm it.

The Sand river fault.

Repeated visits have been paid by Mr. Fletcher to both the Millstone-grit series of the Joggins section and to these beds for the sake of comparing them in groups, but without recognition of similarity. Some faulting does occur at Sand river in the cliffs, but it is not detected on the brooks inland and the disturbances have every appearance of being very local and of but slight geological importance. There is also no such change in the character of the deposit as a fault of the required magnitude would be expected to exhibit. In fact there is less change noticeable there than at other portions of the shore where there are no disturbances of any kind. For instance at Birch cove, a buttress, of the sandstones, stands out from the general line of the cliffs and being of a different colour, appears, when viewed at a distance, as a piece of faulted ground. The change from the general gray colour of the series to a reddish hue between vertical lines is absolutely without any faulting or break in the bedding planes.

Reasonable conclusion.

No other conclusion than that reached by Mr. Fletcher seems reasonable after his very careful survey and repeated stratigraphical comparisons of the several theoretical divisions of this unrivalled section of the Carboniferous rocks; and that not only does the whole distance from Mill creek to Shulee represent an unbroken ascending series but that thence onward the upper beds are continued without serious faulting to Spicer cove, where the formation ends in a heavy bed of red conglomerate resting on the volcanic rocks of the Cobequid ranges.

No unconformity.

It is interesting to find that here no unconformity has been detected although a distinct separation in the Carboniferous sequence does occur elsewhere, as at New Glasgow,* and as at Hard Ledge, Maringouin, where an overlap is clearly exposed. There the nearly horizontal upper strata are seen to rest on moderately inclined Millstone-grit rocks, and at the contact fragments of the latter are included in the former. This exposure is at a place where a drift was at one time driven in on a bed of black fire-clay for coal, and it is near a well-

* Annual Report, Geol. Surv., Can., 1890-91, Vol. v, (N.S.) pp. 109 P.. Trans. N.S. Instit. Sc., 1893, pp. 272-3.

marked syncline in the Millstone-grit that has its axis dipping 15° towards the west and in the direction of Shepody bay.

Extensive outlier.

For a further comparison of strata on the New Brunswick shore the bay was crossed to Alma, and the cliff section towards Owls head and the great fault there so prominent were examined. These gray rocks there offer an end view of the strip of Millstone-grit that rests on the flanks of the Pre-Cambrian coastal range and continues from Alma to Shepody mountain, forming without doubt an extensive outlier of the lower members of the Millstone-grit rocks exposed in more continuous series on Maringouin, and thus belonging to a horizon much below that of the workable coal seams of the Joggins.

With Mr. Fletcher, Dorchester cape was visited. Here occurs a transition from an extensive series of arenaceous shales and sandstones, of a reddish colour, into an equally well exposed series of the lower members of those gray of colour, which are assumed to be the base of the Millstone-grit. Here they include some beds of dark fire-clay and shale, with a few inches of coal, upon which openings have been made. No encouragement was, or could be given to the prospectors there at work, that further labour might lead to a material improvement in the thickness of the coal. A similar opinion had to be expressed in answer to inquiries respecting the thick shale beds carrying a few inches of coal at Slack cove, on the point of Maringouin. Here, large scales of fish were found in the under clay of the coal.

Repetitions.

In this search for conditions similar to those associated with the Cumberland coal-field, it was noted that there were repetitions, though on a much reduced scale, of the basin north-eastward alongside the prolongation of the coastal range, at the head of the Bay of Fundy; the first and smaller, lying between the pink rocks of Maringouin and Dorchester cape, and the other and larger, to the east of Westcock, wh-re the base of the gray series is upheaved. In this basin, the greatest body of Carboniferous measures is in the neighbourhood of Sackville, and here, under the 'Permian' overlap, the highest beds of the series to be found in New Brunswick, are probably to be located. There is, however, no reason to expect that the highest will reach the horizon of the Joggins seams.

Unconformities.

In company with Dr. Ells, the contact of the gray series with the overlying 'Permian,' was sought for, and what was considered an unconformity, could be made out at several points. One of these is seen near the Westcock watering tank, on the Intercolonial railway. It also appeared that the line of contact assumed on the map of 1885,

might be somewhat modified, and the 'Permian' made to include the gray sandstone area about Gaspereau river, and thence, on, to Cape Tormentine, and also to run further inland, so as to include strata to the head of Shediac bay. In the other direction, south of Baie Verte, it should include the gray rocks of Halls hill towards Jolicœur, but the ridge from Mount Whatley to Aulac, should, as shown, remain Millstone-grit.

At Coal branch, near Harcourt, referred to in 1901, by Prof. Bailey, a considerable sum was expended in sinking a shaft of large size, to find a seam of coal, said to be six feet thick, and to have been struck in a bore-hole. The shaft cut only the 16-inch coal, mined in the adjoining river bank.

Search for petroleum.

The New Brunswick Petroleum Company have continued a vigorous search for oil, near St. Joseph's college and across to the Petitcodiac river, and the mouth of Weldons creek; some 14 holes have been bored, and oil got in several of them. Some of these holes have been put down to depths of over 1,000 feet. All are in the Albert shales, though in some cases, they were started in the gray sandstone, which in places caps the older strata. Several of the holes are coupled in series, and fitted with pumps and tanks. In the fall, three rigs were in operation at the same time, in the strip of Albert shales intruding between the Peticodiac and Memramcook rivers.

Albertite.

At the Albert mine, Mr. Robinson exposed, east of a fault, a branch of the original Albert vein, as much as two feet in thickness, and of sufficient importance to warrant further exploration, as the 'coal' will bring at least $14 a ton for varnish making.

Section.

Late in the fall another bore-hole, No. 8, was put down by Mr. John White, at a distance of 500 feet from No. 5, and at a depth of 177 feet some 20 inches of coal was found. In this hole a double core barrel was used, and the section obtained was as follows:

Journal of No. 8 Bore-hole at Dunsinane.

1902.		Ft.	In.
Oct. 23,	blue clay	10	0
"	red marl	7	0
"	" and sandstone	19	0
"	sandstone, mixed, light and red (mottled?)	5	0
"	" " with red marl	15	0
"	blue hard rock	4	0
"	red marl	3	0
Oct. 31,	" with sandstone	19	0
Nov. 1,	bluish fine hard	3	0
"	blue shale	3	0

1602.			Ft.	In.
Nov. 1, red marl and sandstone			22	0
" red and blue sandstone, with a little gray shale			8	0
" red and blue hard marl			10	0
" blue, fine hard rock			6	0
" red and blue mixed marl			5	0
" blue, fine stone			9	0
" red marl,			7	0
" red and blue sandstone			8	0
Nov. 17, dark blue shale			1	0
" blue shale			9	6
Nov. 19, coal	1	8		
" shale	0	8		
" coal	0	4		
" shale	0	10		
" hard rock	0	8		
" shale	0	5		
" fire-clay	0	3		
" coal	0	4		
			5	2
" hard pavement			2	0
" blue shale			14	0
" sandstone			15	0
" blue shale			2	0
" sandstone and conglomerate			53	0
" shale			3	0
" sandstone and conglomerate			77	0
			344	8

On comparing this journal with that kept, in other terms, of bore-hole No. 1 a similarity is noticeable and there seems to be a strong probability that they relate to the same strata down to the coal bed. Similarity of sections.

For the sake of comparison, the section of coal and associated strata struck in No. 5 bore-hole may here be given. This hole was bored without a double core barrel, and at 135 feet gave the following record in descending order:—

Coal	20 inches.
Light coloured soft shale	18 "
Coal	6 "
Soft shale	9 "
Dark shale	3 "
Black shale	6 "
Gray shale	6 "
Sandstone	18 "

The seam met with in these bore-holes is not regarded locally as the same coal as that opened at White's mine on the brook side, although the record of the borings seems to correlate fairly well with that kept of the deep No. 1 hole.

The map of 1885 shows the Intercolonial railway, at Calhoun's mills on the Memramcook river, as cutting through a granite boss about a Granite bosses.

mile in length. This is overlaid on its northern and eastern sides by sandstone beds of an horizon somewhat above that of the gray conglomerate which is so prominent a feature at Dorchester, the copper mine and the Bay shore. Another similar boss, but smaller in size, was this year observed on the brook near the head of McManus's mill-dam, four miles to the south-east of the larger exposure. Resting also on it on the eastern side were similar gray sandstones without intervening conglomerates or members of the red series. Against it on the south are highly inclined beds which at one time were included among the Lower Carboniferous. At the granite boss by the brook side was a small mound of highly altered very coarse conglomerate of uncertain age, and a larger exposure of the same rock occurs a mile further towards East Memramcook, here protruding through the superficial till. This larger mound, or its concealed extension evidently supplied the numerous boulders with which the neighbourhood is strewn.

Geological Observations in Northern New Brunswick.

Professor L. W. Bailey.

Tobique and Nipisiguit rivers.

Dr. Bell's instructions to me were to the effect that an examination should be made during the months of August and September, of the region about the headwaters of the Tobique and Nipisiguit rivers, the object of such exploration being threefold, viz., first, to add to our knowledge of the topography of a tract as yet only imperfectly known or mapped, secondly, to obtain any additional information available bearing upon the geological age and structure of the same region; and lastly, to make a special examination of certain tracts included therein with reference to their supposed auriferous character.

All necessary arrangements having been made for a two months' stay in the field, the latter was entered upon by way of the Tobique river, early in August, the party consisting of myself, Mr. R. A. A. Johnston, of the Geological Survey staff, whose assistance in many directions I would here gratefully acknowledge, and two guides familiar with the country.

Routes followed.

Owing to the state of the water, as well as for other reasons, it was thought best to at once ascend by canoes to Nictor lake, at the head of the Little Tobique river, and, after a portage to the Nipisiguit, to descend that stream at least as far as the mouth of Silver brook, the latter having been referred to as traversing a part of the district in which the finding of gold had been reported. Upon reaching this stream, after only a cursory examination of the country traversed *en*

route, an attempt was made to ascend it with a view to panning operations on the materials of its bed, but these, consisting almost solely of large blocks of felsite and granite, with little or no fine sediment, proved so unpromising, while the difficulties of the ascent, owing to the density of the vegetation bordering and in part covering the small stream, were so great, that all hope of effective work of this character was soon abandoned. A similar attempt was also made upon the Little South Branch, which joins the Nipisiguit about one mile and a quarter below the mouth of Silver brook, but with the same result. The immediate vicinity of the Nipisiguit, having been thus found to be altogether unfavourable to prospecting operations, our attention was at once turned to the other two objects of our journey, it being our intention, later in the season, to reach the sources of the stream mentioned above by the way of the other or Serpentine branch of the Tobique, it having been understood that in the latter direction, the conditions for the search of gold were more favourable.

Professor Ganong's work.

In entering upon the study of the topography and geology of the Nipisiguit country, as well as on that of the Tobique, we found ourselves greatly assisted by the work previously done, especially in the former direction, by Prof. W. F. Ganong during the last few years. The results of this work are embodied in a series of articles contributed to and published by the New Brunswick Natural History Society, and include, besides the first instrumental survey of Nictor lake, the fixing of the position of the more prominent hills and hill ranges along the entire length of the Nipisiguit, the determination of the altitude of many of them, and the assignment to them, according to a definite system, of distinctive names, by which, it is hoped, they may in future be known.

Heights of hills.

Not thinking it desirable to lose time by attempting to duplicate what had already been well done, our attention so far as topography was concerned, was mainly directed to the actual measurement of some of the hills of which the altitude had been only estimated by Prof. Ganong. Among these may be mentioned, in particular, the eminences designated as Mount Charnisay, Mount Wightman and Mount Walker, the last two having, respectively, the elevation of 630 feet, and 900 feet above the river, at their base.*

In connection with the topographical observations, some interesting geological facts were at the same time noted.

---

*These results have not been corrected for air temperature, and are only approximate. If 900 feet be added as representing the probable level of the river at this point (Ganong gives 875 feet for the mouth of Portage brook), these numbers become respectively 1,530 feet, and 1,800 feet above sea level.

Previous work in this region.

Without entering here into a detailed review of work previously undertaken in this region, it may be observed that in the Report of Progress for 1879–80, the tract of land traversed by the Upper Nipisiguit, together with a very large area lying on either side of that stream, was described as being probably of Pre-Cambrian age, and was so represented in the map-sheet issued some years later (1887) as illustrative of the geology of the northern highlands of New Brunswick. In each case the rocks were described as consisting mainly of crystalline felsites, sometimes becoming syenitic by admixture of horneblende, and in places associated with gneisses, felspathic and other schists, supposed to be of equivalent age with resembling rocks in the southern counties of the province. The view referred to was generally accepted, and seemed to be confirmed by the observations of later explorers, including Dr. R. Chalmers, Mr. W. McInnes and Prof. Ganong, neither one of whom seems to have observed anything inconsistent therewith. It was also shared by the writer, who, as early as 1864, made a traverse of the Tobique and Nipisiguit rivers, and described their more obvious features, though without attempting to assign to any particular age, the felsites which are such a predominant feature in the hills about the sources of these streams. Yet the facts observed by us during the past summer, not only upon the occurrences noted above but at many other points, are such as to suggest the possibility of a somewhat different view being entertained as relates to portions at least of the area under review.

New interpretation suggested.

The first facts bearing upon this possible new interpretation, were observed upon the summit of Mount Wightman, situated nearly opposite the mouth of the Little South Branch, and seventy-one miles above the town of Bathurst, where the felsites, instead of possessing the uniform and highly crystalline character usually associated with Pre-Cambrian terranes, were found rather to present the character of rhyolites and feldspar porphyries, associated with conglomerate felsites and breccias, which closely recall some members of the felsitic series which in the Geological Survey report for 1870–71, were included in the Silurian system, as found around the shores of Passamaquoddy bay, especially above the towns of Eastport and St. Andrews. Like the latter they are also often markedly epidotic and in places coarsely amygdaloidal, containing, in addition to blotches of chlorite and calcite, blebs resembling pebbles of white quartz, in the form of miniature geodes lined with minute quartz crystals. It is true that similar features distinguish many areas of so-called Huronian rocks in the southern counties, but they are there associated with chloritic, hornblendic and hydro-mica schists and slate conglomerates, usually highly

coloured, none of which have been observed by us in the hills of the Upper Nipisiguit. Another interesting feature, is the fact that upon Mount Wightman the possibly sedimentary nature of the felsite beds is indicated by the occurrence of strongly defined colour bands (usually reddish in a gray rock) and in such a position as to show that the strata are not far from horizontal. This being the case, it is not to be wondered at that these felsites should spread widely, that they should be essentially alike over large areas, and that in connection with the debris with which all the hillsides are deeply strewn, they should hide from view any beds of a different character upon which they may rest. Thus all the high hills lying between Nipisiguit lake and the Portage stream, a distance of fourteen miles, would seem to be thus constituted, and it is certainly the case with Mounts Charnisay, La Tour, Wightman and Walker, except that the latter is in part composed also of bright red syenite, which is probably intrusive. So the eastern end of the Green range and the so-called Feldspar mountains show associations of reddish and gray feldspar-porphyry with imperfect syenites. But that a rock of a different character does underlie a part, if not the whole of the felsitic area, is possibly indicated by facts observed in the ascent of Bathurst mountain on the Peak of Teneriffe, an eminence lying between the two ranges last mentioned and which from its prominence is familiar to all travellers upon the Nipisiguit.

Strata nearly horizontal.

Bathurst mountain.

The hill last named which attains, according to the observations of Prof. Ganong, an elevation of 2,108 feet above sea-level, is remarkable for its concealed form, the steepness of its ascent, and the small area which crowns its summit. It has always been supposed to consist, with the hills around it, of felsite only, and one might readily make its ascent and reach no other conclusion. Yet at certain points upon its slopes are to be seen exposures which show that this view is open to question. These exposures are to be found in ravines along the eastern side of the eminence at an elevation equal to about one-third of the entire height of the hill, and instead of felsite consist of heavy beds of coarse conglomerate and sandstone, dipping north-westerly at an angle of 40°. It was thought at first that there might be remnants of a newer and unconformable formation lying protected in a basin of older rock, but closer examination showed that not only are they covered by felsitic beds but that they clearly alternate with the latter. Thus we have here further indications that the rocks of the region are apparently bedded, that they lie at comparatively low angles, and that in addition to volcanic and semi-volcanic materials they include others of distinctly aqueous clastic origin. Moreover, these latter are wholly unlike any Pre-Cambrian rocks to be seen else-

Possibly not all felsite.

where in New Brunswick, and in many respects they closely resemble some of the sedimentary beds forming characteristic members of the Silurian system. In particular, the conglomerates, which like the sandstones are of a gray colour, more or less blackened with manganic oxide, while consisting largely of pebbles of white quartz, have associated with these, fragments of black silicious slate or petrosilex, just as do the conglomerates which occur near the base of the Silurian system in the valley of the Beccaguimec river in Carleton county or along the Aroostook river in the State of Maine. The sandstones also find their counterpart in closely resembling beds in each of these localities as they do upon the Seigas river in Victoria county, in these latter cases carrying typical Silurian fossils. We were not fortunate enough, in the limited time at our disposal, to find organic remains in the sandstones of Mt. Teneriffe, and in their absence it would be premature to predicate anything too positively as to their age but unless our observations, which were necessarily limited, are incorrect, they suggest, as already stated, for the structure of the region a different view from that previously entertained, and must be considered as an important factor in any further exploration of the region.

Conglomerates.

No fossils found.

A key to the supposed structure having been obtained as applicable to the upper Nipisiguit country, the idea was at once suggested that a similar structure might prevail elsewhere, and especially about the sources of the Tobique river. To test this point, an examination was first made of Bald or Sagamook mountain, almost the highest eminence in New Brunswick, which overlooks Nictor lake at the head of the Little Tobique. Here again felsite rocks, as first described by the writer in 1864, constitute the conspicuous parts of the mountain, especially near its summit, and until recently were believed to constitute its entire mass, except that, as observed by Dr. Ells and recently by myself, there are, at the base of the hill, towards its eastern end, ledges of greenish-gray chloritic and felspathic schists and slate conglomerates. These have been described as being nearly vertical and as dipping away from the felsites of the mountain; but though it is by no means easy to determine their true attitude, I am disposed to think that they are lying at a low rather than a high angle, and that the latter appearance is really due to their strongly pronounced cleavage, This view derives some confirmation from the fact that at the eastern end of the mountain, overlooking the Nipisiguit portage, the lower half of the eminence was found by Mr. Johnston, to consist of slates and the upper portion of felsites, the latter showing distinct bedding at a low angle, and again by what is seen upon the opposite shore. Here, as well as upon Visitor island, the same slaty

Probably lie at a low angle.

rocks, which are largely slate conglomerates, are again well exposed, and give the same appearance of highly tilted strata, but in ascending Mt. Gordon, at the base of which they lie, repeated alternations of greenish chloritic schists, schistose grits and slate conglomerates occur in attitudes which indicate but little inclination. Finally, towards the western end of Nictor lake, near Armstrong brook, the shores previously represented as of Silurian slates, show ledges of felsitic rock, varying from gray to reddish in colour, and with a distinct dip of only 5°. Thus the sedimentary nature of the beds around the lake, the intimate association of felsitic or rhyolitic aqueous deposits, and the generally low inclination of the strata, accord with the observations made upon the Nipisiguit, and go far to indicate that like relations exist in the intermediate district and far beyond the latter. Felsite at Nector lake.

It had been my intention, while at Nictor lake, to examine in detail all the hills in its neighbourhood, including Mounts Bailey, Franquelin and Bernardine, as well as the somewhat more remote eminences, such as Mounts Head and Carleton (the latter the highest mountain in New Brunswick), but a very serious accident having happened to one of our guides, making it necessary to seek surgical aid, this undertaking had, for the time, to be abandoned. Subsequently, all efforts to obtain another competent guide in the place of the one disabled having proved fruitless, all further work for the season was abandoned, by Dr. Bell's direction. Accident to guide.

Owing to the circumstances alluded to, no examinations were made of the Right Hand branch and its tributaries, nor of the area between these and the Nipisiguit, drained by Silver brook and the Little South branch of the river last named. I am, therefore, unable to add anything upon the subject of the auriferous character of this district to what has been said by Dr. Chalmers and by myself in previous reports, except to state that so far as regards the region actually examined by us, including the felsitic hills and their associated rocks, no facts were observed which would favour the idea that these contain gold, or indeed any metal in workable quantities. Quartz veins are of rare occurrence, and such as were observed seemed to be quite destitute of mineral contents. The beds of the streams examined also, consisting almost solely of large blocks of felsite or syenite, offered but little encouragement to the prospector. It may be added that in all these respects the region of Nictor lake and the sources of the Nipisiguit is somewhat strongly contrasted with that of the Serpentine, where the rocks are mainly schists or slates, and abound in quartz veins. The extension of these latter beds would probably cross the upper part of Silver brook on the Nipisiguit and, therefore, include the area whose Occurrence of gold not probable.

supposed auriferous character was an important factor in determining the investigations detailed in this report. But this and many other important questions relating to the northern highlands must await, as they should certainly receive, further careful study.

Growth of forest.

In addition to the above summary I have only to say that, in accordance with Dr. Bell's instructions the obtaining of data bearing upon the rate of the growth of trees in areas previously deforested was kept constantly in mind, but little could be learned, mainly for the reason that over the larger part of the region visited by us the forests are still in virgin condition. In the settlement of St. Almo, however, upon the Tobique, which was fire-swept about thirty years ago, and where the growth destroyed consisted of white birch, spruce and poplar, with many pines, the trees are now mostly white birch, attaining a size of four to ten inches in the butt, with spruce from twelve to thirteen inches, but with little or no pine. In some instances * a period of twenty-eight years has brought a tract covered only with a low scrubby growth of spruce to a condition capable of being cut to advantage. Some tracts, on the other hand, seem incapable of restoration, or only of a very slow one, the growth apparently as a result of the nature of the soil or the abundance of boulders being at all times low and scrubby.

Surveys and Explorations in Richmond, Cape Breton, Kings, Cumberland and other Counties of Nova Scotia.

Mr. Hugh Fletcher.

Winter office-work.

Mr. Fletcher spent the winter of 1901-02 in the ordinary routine work of the office, including correspondence and the compilation of plans and sections from surveys made in the field by himself and his assistants, during the previous summer, as detailed in the Summary Report for 1901 pages 208 to 214.

He left Ottawa on April 15 for Cape Breton to examine borings made at Coal brook in the Richmond coal-field near the line of the new railway from the Strait of Canso to St. Peters and Louisburg. He returned on May 1, but left again for Nova Scotia on June 16, with Mr. A. T. McKinnon, and did not return until January 2, 1903.

Field work of a general character.

Owing to the activity in various mining districts of the province and the demand for geological information of use in certain explora-

* The tract specially referred to is that of the head of the Mamozekel, one of tributaries of Tobique river.

tions and mining operations, much of Mr. Fletcher's time was spent, by Dr. Bell's instructions, in Cape Breton and elsewhere outside the field of his systematic work.

The borings at Coal brook were made by one of the provincial government calyx drills, in charge of Major James L. Phinney, of Wilmot, Nova Scotia.

Boring for coal in Richmond coal-field.

It is stated on page 118 of Part P. of the Report for 1879-80, on the authority of Mr. A. McBean, that two seams of coal occur at Coal brook. Extensive explorations made since that date seem, however, to prove rather that the coal seam opened and worked near the mouth of the brook is the same as that found higher up and that it lies in a narrow basin, parallel to the general course of the brook, along which black shales are well exposed. From the workings near the mouth, from which eighty tons of coal are said to have been shipped, the seam was traced 700 feet, opened again about 1,600 feet further up stream, and followed thence nearly 1,000 feet further. The first drill-hole, about half a mile from the shore and on the top of the bank, is on the north side of the narrow basin, the second was bored at the axis of this basin, where the beds lie nearly horizontal, about 800 feet downstream on the left bank. The first was bored to a depth of 520 feet through blackish and gray argillaceous and arenaceous shales, with several thin coaly layers, light gray or whitish micaceous, pyritous sandstone, often striped, usually fine but with coarse beds. Only one thin red band was cut, about six feet in thickness. The dip of the rocks was 20° near the top while deeper in the hole it steepened to 49°.

Bore-holes.

Thickness of coal.

The second hole, drilled to a depth of 1,020 feet, must have proved the strata for a considerable distance toward Doyle creek. As stated above, only one workable seam of coal was found in these holes. Its thickness is variable. The maximum where uncovered in the brook was three feet two inches, with a two inch parting about six inches from the top, the upper part of the coal being impure. Where cut in the second bore-hole at 170 feet, the coal was one foot eight inches thick, corresponding with the seam as opened in a long trench to obtain fuel for the engine and in a level, 168 feet long, opened by McBean above the first bore-hole. The floor is a dark-gray, fine, coherent sandstone; the roof and overlying rocks are similar. Two other seams of coal, six and four inches thick respectively, were also cut in the deeper hole, as well as a band of red shale six or eight feet thick. The proportion of the core lost in drilling was very small. Some of the light-coloured shales carry *Asterophyllites*, *Cordaites* and other plants, and certain layers consist of a mass of fossil shells beautifully exposed in a cross section.

Explorations at Little river mine.

The red cores taken from a boring immediately north of the mine at Little river indicate either that red strata overlie the coal seams there or that a fault intervenes between the bore-hole and the workings. The latter supposition is that adopted in the map of 1884. On the railway, east of the Buchanan road, a belt of red shale appears to underlie the dark shales on the north side of the basin mentioned above, or along the fault shown on sheet No. 21. Eastward along the railway, dark shales have been cut, but no red strata, and near Shannon lake there are good exposures of gray sandstone like that of the shore south-east of Coal brook. Above the railway bridge over White brook, greenish and gray and drab argillaceous shales and fine sandy flags are succeeded by reddish sandstone, more or less argillaceous, striped or banded, with a nearly vertical northerly dip, an attitude found among similar red rocks in the Falls brook to the westward. From the deep shaft at Rory McDonald's, red shale, like that of Hawkesbury, was thrown out.

Evans island.

On Evans island, search has been made in the gray, blackish and rusty argillaceous shales, many of which contain nodules of ironstone and small seams of coal not far from outcrops of gypsum, as at Little river. Mining has also been resumed at Seacoal Bay (Port Malcolm) mines in the Richmond coal-field.*

Bore-hole for coal at Glendale.

Early in the autumn the calyx drill was removed from Coal brook to Glendale to test the rocks which lie beneath the coal seam described in the section on page 99F of the Report for 1879-80, near which several thousand dollars had been spent in prospecting. In that report it was stated that 'the quantity of available coal in the basin even if the seam were much larger, would be extremely small,' but the possible existence of other seams was also suggested. A bore-hole was put down to a depth of 500 feet, chiefly in gray and reddish argillaceous shales; but no other seams were found. It was begun at the foot of a steep bank of black shale overlying the coal seam. Down River Inhabitants nearer the bridge, borings were also made by Mr. James McDonald, M.P.P. and others, in which coal was found, but apparently not in workable quantity.

At Port Hood mines.

Later in the season, the drill was taken to make trial of the number and thickness of the coal seams in the Port Hood basin, and two holes were bored in the strata underlying the main seam without, however, cutting any other workable seam.

Deep boring north of New Glasgow.

The Pictou Exploration Company is using another of the government calyx drills, which has a capacity of 3,000 feet, to test the

* Report for 1879-80, Part F. page 121.

measures underlying the New Glasgow conglomerate on the west side of the East river Pictou, below Trenton. The drill was placed in Rear brook, where a plentiful supply of fresh water is available, and the rock is in situ with nearly horizontal bedding. Transportation to the spot was convenient, and repairs of all kinds can be readily made in New Glasgow; so that, although the depth to be bored here in order to pass through the whole thickness of the conglomerate and overlying rocks may be somewhat greater than at the mouth of Begg brook, on the Middle river, another site suggested, this advantage may be compensated by those mentioned above and also by the strong probability that being nearer the large seams of the Pictou coal-field south of the North fault, these seams may have an extension in workable form towards this bore-hole, which must in any case be a deep one. It has been put down already to a depth of nearly 600 feet, or about 200 feet into the conglomerate.

In the same county at Foxbrook, south of the coal measures of Westville, a hole has been bored nearly 400 feet, with one of the smaller diamond drills belonging to the provincial government, chiefly through red sandstone and shale coloured as probably Lower Carboniferous on sheet No. 47 of the Nova Scotia series of geological maps. Foxbrook and Hantsport boreholes.

By the enterprise of a few citizens of Hantsport a hole has been bored 1,300 feet with a third government calyx drill, in charge of Mr. Clarence Smith, of that town. The site chosen is in a brook near the boundary between the counties of Hants and Kings, half a mile west of the railway station, at a point where search had previously been made for coal. Gray sandstones and shales of the Horton series. known elsewhere to contain important quantities of albertite, rich bituminous shale and petroleum, lie in the brook with a low northerly dip. To a depth of about 300 feet the drill cut chiefly light and dark gray fine sandstone, underlaid by bluish gray coherent argillaceous shale, containing a few plants and bands of ironstone, to 800 feet, below which gray sandstone prevails. Some of the shales are said to have yielded the characteristic odor of petroleum. At 150 feet a strong feeder of water was struck. Boring for oil at Cheverie.

On Cheverie brook, boring for oil has been begun with a cable drill; and it is hoped that a thorough test will be made of this district, the promise of which was pointed out by Professor H. Y. Hind, of Windsor, more than thirty years ago. In a report on the petroleum indications at Cheverie, Professor Hind stated that although 'feeble external indications are not generally sufficient of themselves to warrant an immediate expenditure of capital, especially in a region where natural petroleum springs are not known to exist at the present time,' yet Bore-holes at Lake Ainslie and Skye Glen.

that 'the evidences of the existence of petroleum at Cheverie are sufficiently strong to warrant the expenditure of capital in a systematic exploration by means of bore-holes.' Oil and bitumen have been found in cavities, joints and fissures of a mass of gypsum, largely quarried in this neighbourhood, which overlies a great body of black shales containing numerous remains of plants and animals and thus 'supplying the material for the supposed source from which petroleum has originated.' The age of these shales is that of oil-producing strata of other countries, the structure of the rocks seems 'favourable to the accumulation and preservation of petroleum,' and there is, consequently, presumptive evidence that deep boring might reach stores of petroleum. 'Exploratory bore-holes can alone decide whether these stores have been exhausted at Cheverie by long continued overflow,' and the cost of such bore-holes should not be very great. Wells have been bored in the oil district of Lake Ainslie, in Cape Breton, *3,260 feet and to a much greater depth at Gaspé, in search of oil. Explorations were made last summer at Skye Glen, one well having reached a depth of more than 1,100 feet, but without success.

Manganese and limestone at Walton.

In this connection a cursory examination was made of the district between Walton and Noel, in which bands of the dark slates and flags of Split Rock and Cheverie also occur, the overlying sandstones and shales being also found near Cheverie. Succeeding these Devonian rocks at the manganese mines west of Walton is a reddish flaggy limestone or marble, overlaid by gray massive limestone. In and near the limestone occur ores of manganese and other metals ([1]) and it seems probable that, as the demand for limestone leads to the quarrying of these beds along the contact, bodies of these ores will be discovered, as large as any that has been mined, without the expense and uncertainty that at present attends their extraction.

In continuation of the bore-holes put down by the Hon. David MacKeen along the outcrop of the Tracy seam ([2]) a diamond drill hole was bored by Mr. Cottrell, to a depth, it is said, of more than 300 feet, near Murdoch McLean's. Halfway between Cochran lake and Macdonald lake (sheet No. 135), in a slope from which coal was taken last winter for local consumption, the seam is said to have measured four feet five inches. It is hoped that these explorations will be extended further to the westward.

---

*Report of Progress Geol. Surv., Can., 1882-84, Part H, page 90, and Annual Report, vol. X. (N.S.), page 102A.

[1] Jour. Can. Mining Inst., vol. I., p. 227.

[2] Sum. Rep., Geol. Surv. Can., 1901, p. 208.

The Mullins seam also was exploited in a shaft near Senator MacKeen's bore-hole at Lynk lake, where it is stated to be four feet and a half thick, instead of three feet as in the section given of the bore-hole ([3]). On the Mullins seam.

A visit was also made to recent developments by Mr. C. A. Meissner for the Dominion Steel Company, among the crystalline limestones of Eskasoni ([4]) in the immediate neighbourhood of the interesting exposures of Cambrian fossiliferous rocks studied by Dr. G. F. Matthew ([5]). Although the developments failed to discover limestone suitable to supplement that at present obtained in large quantity for the furnaces from the Marble mountain of West bay ([6]) yet they afforded interesting contacts with the surrounding felsitic, gneissic and syenitic rocks.

I also visited Middle river, in which several Chinamen have been washing for gold and Mr. Scranton has erected a small crusher and is still mining the quartz veins of the Second Gold brook ([7]). His trenches and pits have exposed several veins from four feet downward and into one of these he has driven a long tunnel on the line of strike of the inclosing slates. In the quartz there are fine samples of gold resembling that found in the sand of the brook, finely spattered throughout the veinstone or in leafy layers in the joints. Gold of Middle river.

During a portion of the months of July and August, I was with Mr. H. S. Poole and Dr. R. W. Ells at some of the more important Carboniferous sections on the Nova Scotia and New Brunswick shores of Cumberland basin and Chignecto bay ([8]) to compare the different series of Carboniferous rocks with those of the well-known section at the Joggins. The difference between the lowest beds of this section and those called Permo-Carboniferous is well seen on Minudie point, where the latter consist of gray, blackish and red coarse glistening sandstone, with a few bands of red argillaceous shale, pebbly patches and friable conglomerate, like the Permo-Carboniferous of other districts, but also like certain beds below the Millstone-grit at Downing cove. Examinations on Cumberland basin.

---

[3] Sum. Rep. Geol. Surv. Can., 1901, page 209.
[4] Report of Progress Geol. Surv. Can., 1876-77, pp. 411, 427, 456.
[5] Sum. Rep. for 1901, p. 225 and Matthew's Report on the Cambrian of Cape Breton. (Just out.)
[6] Report of Progress Geol. Surv. Can., 1877-78, pp. 29 to 32F.
[7] Annual Report Geol. Surv. Can., 1882-84 (N.S.), part H., pp. 29 and 97; Professor Woodman's report to the N. S. Department of Mines, 1898, page 12.
[8] Sum. Rep. Geol. Surv. Can. 1902, p. ——.

Line of bore-holes near Mapleton.

In extension of the borings of 1901 westward from Leamington towards Mapleton, ([9]) sixty-six holes, seventy-two feet deep and under, were bored on a line following the south side of Rattling brook for about two and a half miles to Hoeg brook, along a belt of gray argillaceous shale and sandstone overlaid by red shale and sandstone, the whole series apparently overlying the coal seam passed through near the top of the 715 feet bore-hole at Mapleton. ([10]) The gray strata resemble in texture and composition those below the coal measures of the south branch of Black river, but on that section, as elsewhere stated, no red rocks appear. Moreover, no fault has been detected that could separate these rocks from the coal measures to the north-eastward, and the tracing of the small coal seam eastward from the Mapleton bore-hole has made its identity with the Barlow seam, more than ever probable. In any case it is important that this region should be thoroughly explored, since, even if these are lower measures, we might expect that, with their north-westerly dip, they would be overlaid somewhere by strata containing workable seams of coal.

Barlow seam.

Upper Maccan river.

The Upper Maccan river, below Captain Mills, seems to follow a flat anticline, the dips being at a very low angle. In adjoining brooks, which enter from the north below Hoeg brook and near the Etter road, the opposite dips of another anticine are well defined in a gray sandstone full of fossil plants. Above these brooks the river bank shows more than fifty feet of red argillaceous shale, probably that found by bore-holes far to the eastward of Hoeg brook.

In Henry brook, red rocks, precisely like the latter but probably much lower, have a low northerly dip, are interstratified with gray fine sandstone, and are succeeded to the southward by gray sandstones and shales containing rootlets. At and above the fork, coarse grit and conglomerate occupy the brook.

Coal probably traced to Hoeg brook.

The strike of the small coal seam at the deep Mapleton bore-hole would, if produced, carry it to Hoeg brook near the road. Here also a quantity of drifted coal was found in the brook near Mr. Willard Gilroy's house. Two boreholes put down hereabout found apparently the two bands of red shale and sandstone that underlie at no great depth the coal seam, which must in this event outcrop a short distance north of the road. As already stated, this coal is probably the equivalent of the highest seam in the section of Coal Mine brook, and it therefore becomes a question of great commercial as well as scientific

[9] Sum. Rep., Geol. Surv. Can. for 1901, p. 214.
[10] The cost of and time occupied in this boring are given in the report of the Depart. Mines for Nova Scotia, 1874 page 26.

interest to determine what has become of the underlying workable seams of the latter section and their relation to the conglomerate along the northern slope of the Cobequid hills at Rodney, Mapleton, Southampton, Newville, and Apple river, as well as to that which underlies the coal at the Chignecto mine on the north side of the basin which may be in part or wholly its equivalent.

Relation of coal measures to conglomerate of the Cobequid hills.

Between Mapleton and East Mapleton, a thickness of about 2,500 feet would seem to include all the strata underlying the bore-hole seam to the Pre-Carboniferous granite of the hills. Of this thickness 715 feet cut in the borehole are of fine texture and associated with thin coaly layers. Would this hole if continued have touched the conglomerate of the hills south of Upper Maccan river? Does this latter represent coal measures or other fine sediments at a distance from the hills? Or has a fault or unconformity north of it escaped observation? A glance at the accompanying map will serve to illustrate these questions.

Possibility of reaching workable coals by deep boring.

It has been pointed out that on the north side of the syncline which has its axis near the shore at Shulie there are exposed about 1,500 feet of carboniferous strata, while from the same axis southward less than 5,000 feet appear, chiefly coarse sediments which may represent only the upper part of the section on the north side. Mr. John Rutherford in 1870 suggested the probability * that near Apple river, workable seams may lie at a considerable depth from the surface. On the shore section, as on that from East Mapleton to the Springhill coal mines, no great fault has been observed; and the geological structure as now understood seems to justify the boring of one or more deep holes in the hope of determining whether the workable coals are cut off by faulting, replaced by barren strata along this line, or concealed by unconformity or overlap, and can yet be reached and mined.

Coal mines

Work has been vigorously prosecuted at the Springhill mines, and a smaller yield of coal obtained from the Joggins, Jubilee, Strathcona, Chignecto and other mines on the north side of the Cumberland coal basin. The Chignecto colliery has been reopened by the Maritime Mining Co. and the slope sunk to a depth of 825 feet.

Acknowledgements.

In my investigations I have has been again greatly assisted by the kindness of Mr. J. R. Cowans, the gentlemen mentioned on page 214 of last year's Summary Report, Messrs. J. A. Johnson, J. G. Rutherford, David Mitchell, James Baird, G. B. Mills, and others.

* Trans. North of England Inst. M.E., vol. XIX, page 117.

Copper ore of Cumberland county.

Some time was spent in an attempt to define more closely the boundaries of the various subdivisions of the great mass of carboniferous sediments lying between Maccan and Tatamagouche rivers, in the area covered by sheets 59, 60, 61 and 62 of the Nova Scotia series of geological maps. These strata include the copper ores of Chisholm and Canfield creeks, the Palmer and Chisholm mines and other workings in the Wallace, Philip and Pugwash rivers, which have yielded no adequate return for a very large expenditure of money during the last ten years; the unimportant outcrops of coal at Roslin Hill, South Victoria, Conn's mills, Malagash point, Oxford junction and other places; the gypsum and selenite of Plaster cove, Saltsprings and River Philip; and the celebrated gray sandstone of the Wallace quarries. As these examinations are still unfinished, the results will not at present be referred to. The difficulty of distinguishing the gray sandstone of the Upper Carboniferous of Ragged reef from the Millstone-grit sandstone of the Lower Cove quarries, the Lower Carboniferous red shales and sandstones of Downing cove from the Upper Carboniferous of McCarron cove, and other groups on the Joggins section, gives some idea of the difficulties encountered when these rocks are traced inland towards Athol, Mapleton and points farther east, where exposures are not so good and large portions of fine sediment are replaced by coarse grit and conglomerate.

Copper ores.

The mode of occurrence and the character of the copper ore of the district have been sufficiently described in the Annual Report for 1889-91, part P., page 186. It is in the form of nodules and films of chalcosite usually in dark-gray and blackish more or less carbonaceous beds.

The Lower Carboniferous marls near the mouth of Pugwash river are used as a source of supply for the brickworks; and the adjoining beds of limestone have been extensively quarried.

Brookfield iron mine.

With Mr. F. H. Chambers, the manager, a visit was paid to the Brookfield iron mine, the ore from which is shipped over a short tramway to the Intercolonial railway for use at the Ferrona furnaces. From this deposit, described in the Annual Report for 1889-91, part P., page 177, as near the contact of Devonian and Carboniferous rocks, 20,000 tons of excellent limonite are said to have been extracted. The ore is near the surface, overlying Lower Carboniferous rocks having been eroded, but in the immediate vicinity is a gray limestone of this formation, so that some of the hollows or basins separated by protrusions of Devonian strata seem worthy of being tested.

My assistants, Messrs. M. H. McLeod and A. T. McKinnon, in Kings and Annapolis counties surveyed the district westward from Salmon-tail and Gaspereau lakes, for sheets Nos. 98 and 99, their south line running from Salmon-tail lake to the Nictaux river and being in granite as far as Allan lake. North of the granite lie Cambrian and Silurian slates and quartzites which are in contact with soft, crumbly sandstone of Triassic age, along the foot of the South mountain. This sandstone, deeply eroded in the valley of the Cornwallis and Annapolis rivers, rises to the summit of the North mountain where it is cut off by basaltic trap. The section is thus similar to that between Gaspereau river and North mountain, described in the Summary Report for 1901, page 211 and illustrated by an accompanying map. The district joins that described in the Summary Report for 1894 and again, by Professor L. W. Bailey, in Vol. IX, Part M. In its western portion lie the iron mines of Torbrook and Nictaux.

Surveys by McLeod and McKinnon in Kings and Annapolis.

The roads were surveyed with odometer, the brooks and lakes chiefly by pacing between the roads. From September 25 to October 4, Mr. McKinnon collected minerals in Cumberland county to be used for educational collections ; he obtained two barrels and a half of fibrous gypsum at Clarke head * and two and barrels a half of agate at Two Islands, packed the specimens and forwarded them to Dr. Bell at Ottawa.

Minerals for collections.

Except in the western part, there are few minerals of economic value, but the district is well adapted to agriculture and fruit growing. Besides the apples, plums, pears and other fruits for which the region is noted, the culture of the cranberry has for some years afforded a profitable means of utilizing the bog lands of the Annapolis valley between Kentville and Middleton and has become one of its most important industries. The large Aylesford bog and other flats in which the water can be drained to about a foot beneath the surface, after the removal of the peat or turf, are extensively used for this purpose. The mud is ploughed, harrowed, mixed with the underlying or transported sand, and planted with vines in shallow furrows about two feet apart. Woods, bushes and grass have then to be kept in check until the vines get matted over the ground and are ready to yield, after which, with a little judicious care, fifty barrels or more to the acre may be gathered for many years, although there may be seasons in which the crop is shortened or even destroyed by frosts in June and September, before the berry has attained its full size, or the berry-worm may cause the fruit to fall off or rot before it is fit to pick.

District adopted to agriculture and fruit growing.

* Dawson's Acadian Geology, page 105.

South river.

In many parts of the district the rocks are heavily covered with red sand and gravel, but along the banks of the streams they are frequently exposed. On the South river, above the mill at the road west of Morristown, blackish and dark-gray flags, containing much pyrite and some mica, resembling the rocks of the Black river of Gaspereau above Whiterock, are cut like them, by masses of greenish granular diorite, and belong, no doubt, to the upper or clay-slate group of the gold-bearing series. At and above the fork of this river, the slates are foliated and gneissic, interstratified with layers of spotted or andalusite-schist, broken through by masses of red coarse granite; and gray gneiss and granite occupy the eastern branch for some distance until succeeded by granite.

Red and green slates.

A short distance below the mill, blackish slates are succeeded by greenish slates, like those of Canaan, cut by intrusive dykes of greenish and gray crystalline diorite. Below Factorydale, the greenish slates give place to red and green mottled slates, overlaid by bright-red slates; but none of the quartzites of Whiterock appear on this section.

Dykes.

Westward through Harmony and at a school-house and hall, blocks indicate apparently a great dyke of greenish crystalline and compact diorite. On the slope of the hill, just before coming to the Fales river, there is a fine outcrop of light-coloured compact and granular diorite and felsite. Above the bridge on this river, greenish and mottled slates, like those which yield *Dictyonema* at Canaan, becomes very porcellanous where in contact with masses of diorite. Down the river they are less altered, and beyond them come red and green mottled slates, showing fine dendritic markings like those of the brooks of Gaspereau, Highbury and Canaan. On the right bank, between these red slates and the bridge above, a tunnel has been driven into black graphitic slates which occupy a narrow belt about a quarter of a mile below the bridge; and about thirty yards farther upstream is the quartzite of Whiterock, Canaan and Highbury, whitish or spotted with red, tilted at a high angle.

Whiterock quartzite.

Similar red shales and quartzites cross the road to the westward. Near the Annapolis county line, on Messenger brook, the first stream east of East Torbrook post office, there are diorite dykes cutting red and blackish slates, which dip northward, include many beds of quartzite and are overlaid by gray and blackish shales and argillaceous sandstones, full of shells, encriorites and corals. These are similar to the slates near the mouth of the Black river of Gaspereau in which markings of plants were found in 1901; they are also like the slates of Deep Hollow, near Port Williams station, from which were obtained

joints of crinoids. At the top of this section, just before it is concealed by the intervale, to be overlaid next by Triassic sandstone, red and greenish slates, well exposed at the foot of a gorge, contain fossils at first mistaken for *Dictyonema Websteri*, but determined by Dr. Ami as probably a new species of *Tenestella* in the same beds with numerous Silurian fossils of species enumerated by Professor L. W. Bailey in his report on the geology of south-west Nova Scotia.*

On the east side of the brook is the Messenger mine, containing a six-foot bed of hematite, that was mined to a depth of ninety feet, the ore being similar to that of Torbrook.†

Nova Scotia Gold Fields.

Mr. E. Rodolphe Faribault.

Mr. E. R. Faribault was engaged during the winter 1901-1902 in plotting the surveys made the previous summer in the counties of Halifax and Lunenburg, Nova Scotia, referred to in the Summary Report for 1901, pages 214 to 221. Office work by Mr. Faribault.

The plans of the gold districts of South Uniacke, Montague and Lake Catcha, surveyed in 1899, and completed up to date and the plan of Tangier, surveyed in 1898, have been published. Plans of gold district published.

The plan of the gold district of Gold river, surveyed the previous summer, was also completed, but its publication has been deferred in the hope of getting more data in the field to work out its structure more satisfactorily. A further examination of the district was consequently made last summer, and although the structure is still incomplete at certain points, it is thought better to have the plan published immediately, as it will be useful to mine owners who are contemplating new developments.

Mr. Owen O'Sullivan has made good progress in the compilation of the one-mile to an inch map upon which he was engaged last winter. The compilation extends now as far west as the line of the Intercolonial railway between Elmsdale and Bedford, and from the road leading from the latter place to St. Margaret bay, it extends south- Publication of maps.

* Annual Report Geol. Surv. Can., vol. IX, (N.S.) part M., pages 94 to 97.
† Acadian Geology, pp. 563 and 571; Supplement, 1891, page 20.

ward to the shore of the Atlantic. It is expected that the following map-sheets will be ready for publication before leaving for the field:

No. 53, Lawrencetown sheet.
No. 54, Musquodoboit Harbour sheet.
No. 55, Middle Musquodoboit sheet.

While the compilation of the following sheets will be nearly completed:

No. 66, Elmsdale sheet.
" 67, Waverley "
" 68, Halifax City "
" 69, Prospect "

Map of Halifax and vicinity.

The Halifax City sheet will be especially interesting and useful, and it is deemed advisable to issue, for local purposes, a special map of the *city of Halifax and vicinity*, on the same scale, but larger than the ordinary 12 x 18 inches size, with the city as a centre and including Bedford, Waverley, Montague, Cow Bay, Herring Cove and the country to the east and west of the city for some twelve miles.

Field work.

On the field work accomplished in the Nova Scotia gold-fields during the past season, Mr. Faribault reports as follows:—

In accordance with your instructions, I left Ottawa on June 7, for Nova Scotia to resume last season's surveys in connection with the mapping of the Lower Cambrian gold-bearing series of Nova Scotia and to continue the study of the structure of the gold mining districts of the province.

Acknowledgments.

In the performance of my field-work, I have received much information and assistance from miners and other persons, and I wish to offer especially my acknowledgments to Dr. E. Gilpin, inspector of mines; Dr. M. Murphy, provincial engineer; Sheriff Donald Archibald, and Messrs. James H. Austin, Crown Lands Department; Harry Piers, curator provincial museum; Henry S. Poole, F. H. Masson, Rufus O. Bayer, Joseph H. Austen and Fred. P. Ronnan of Halifax; G. J. Partington, A. B. Cox, W. F. Fancy, John McMillan, Chas. D. Maze and Stephen M. Giffin of Isaacs Harbour; Howard Richardson, Frank Sweet and S. R. Giffin, of Goldboro; S. R. Heakes and Matthew McGrath, of Wine Harbour; Arthur G. McNaughton and Wm. McIntosh, Goldenville; George. W. Stuart, Truro; A. Kent Archibald, Monroe Archibald and John Worrall, of Harrigan Cove; George Fraser and Laughlin McLean, of Fifteen-mile Stream; Hon. James D. McGregor and Thomas Cantley, of New Glasgow; E. Percy Brown, Dr. D. Stewart, C. W. Crowe, T. H. White, C.E., and V. J. Paton, of

Bridgewater; J. A. Crease and T. R. Prince, of Mount Uniacke Mines; S. G. Lyman, Renfrew; Charles Thompson, Elmsdale; Levi Dimock, West River Sheet Harbour; L. W. Getchell, Caribou Mines; Robert Kaulbach, Middle Musquodoboit; Charles Keddy, Lake Ramsay, New Ross; Dr. Henry W. Cane, New Ross; Prof. G. T. Kennedy and Dr. H. Y. Hind, of Windsor, N.S.; and H. K. Wicksteed, C.E., Mahone Bay, N.S.; also Marland L. Pratt, Boston, Mass. and Paul M. Curtis, Harvard University, Boston, Mass.

I was again ably assisted, during the whole season, by Messrs. Archibald Cameron and J. McG. Cruickshank, who worked in the field until November 19, when they began the plotting of their surveys, which is now completed. **Assistant's work.**

Surveys in Lunenburg County.

Mr. Cameron was engaged the greater part of the season on a survey of that part of the county of Lunenburg which lies west of La Have river and adjoins the counties of Queens and Annapolis. **Lunenburg county.**

Mr. Cruickshank assisted me until August 11, in surveying gold districts in the counties of Guysborough and Halifax; then he joined Mr. Cameron in Lunenburg county.

The region surveyed measures 12 miles east and west and 30 miles north and south, or about 360 square miles. It is drained by the western tributaries of La Have river, the Petite Rivière and the head-waters of the Pleasant and Port Medway rivers, and an innumerable number of small lakes and streams. The country is generally well settled, mostly by people of German descent, particularly along the coast and valleys of La Have and Petite Rivière. It includes the town of Bridgewater on La Have river and the gold districts of Leipsigate, Voglers Cove and Pleasant River Barrens.

The region is underlaid entirely by the gold-bearing series, folded into parallel upheavals and depressions running northeast and southwest. The strata are less tilted than in the eastern portion of the province, the rocks seldom dipping at higher angles than 45 or 60 degrees. A few of the upheavals have the form of broad elliptical domes, less favourable to the development of interbedded auriferous veins than the sharper anticlinal folds further east. Important auriferous fissure-veins, cutting the strata at acute angles, appear, however, to be more numerous, and those operated at Leipsigate and Voglers Cove have already produced good values. **Gold-bearing series.**

Denudation has also been much less extensive; as a result, the whin rocks of the lower division of the gold-bearing series have not been brought up so extensively to the surface as to the eastward of Halifax, and the slates of the upper division predominate over larger areas.

Structure.

The structure of the rocks of this region has not yet been worked out in such detail as to determine exactly the anticlines and synclines and the cross faults. A few preliminary notes may, however, be given here on the position of the main anticlines.

Seven anticlines.

Seven anticlines and synclines have been recognized across the forty miles of country stretching between the outside islands off Dublin shore and the northern limit of the county, at an average distance of about six miles apart.

The seven anticlines are met with in the following order from south to north.

1. *La Have anticline:* The most southerly anticline cropping out at the surface is well exposed on Hartland bay where it crosses Pointe Enragée and Goff point and running westerly across the entrance of La Have river, shows on La Have islands, beyond which it passes under the sea.

2. The Ovens anticline: This crops out on Green island, at the entrance of Mahone bay, and extending westerly between East Point and Big Duck islands, it runs through the Ovens mine, Rose bay and Five houses, crosses the mouth of La Have river, skirts Dublin shore and runs through Green bay into the sea.

Gold washing at the Ovens.

At the Ovens washings have often been made of the sands and gravels detached by the action of the sea from auriferous quartz veins intercalated in slate on the arch-core of the anticlinal fold.

3. *Indian Path and Voglers Cove anticline:* This begins at the south end of Aspotogan peninsula, where it occurs immediately south of New harbour and Herring cove, and extending westerly through Mahone bay, it skirts along the north side of South East cove on Big Tancook island, crosses Beckman island at its north end and Lunenburg harbour about one mile south of the town and passes through Indian Path mine; thence, running more south-westerly, it crosses La Have river at the Horne brook and runs through New Cumberland, Crousetown, Voglers Cove mine and Port Medway.

Indian Path mine.

At Indian Path, a few main leads were developed and a crusher built several years ago, but they have not been worked to any extent.

At Voglers cove, a very promising fissure-vein cutting across the stratification has recently been operated and found rich in gold; and a few interbedded veins have also been prospected.

Voglers cove mine.

4. Leipsigate and Gold River anticline: From the town of Mahone Bay, this anticline runs westward, passes the north end of Coveys lake and through the town of Bridgewater on La Have river, to the west of which it developes, through Hebbs and Leipsigate lakes, into a broad dome, formed by its intersection with another anticline coming from the north-east through Maitland forks, Vaughan lake and Gold River gold district.

A hurried examination was made of the gold district of Leipsigate and the following notes may be given, subject to revision.

Leipsigate gold district.

The district is situated on the south-western and sharper portion of the dome where an important fissure-vein has been traced for about 6,000 feet in length through four or five different properties, three of which were successfully operated last summer. The vein dips north 70° at the surface and flattens to 55° at the depth of 200 feet, while the strata dip south 50°. The outcrop of the vein describes a long curve almost parallel with the strata; at the German mine it runs easterly across the strata towards the south at a slight angle; further east, at the Micmac mine, it is about parallel with them and at the eastern extremity it curves to the north and crosses the same strata towards the anticline. Consequently the intersection of the vein with the strata pitches eastward at the west end and westward at the eastern end and becomes horizontal between the two. Several pay-chutes already developed seem to occur along the intersections of the vein with certain belts of dark-gray slate favourable to the deposition of gold, hence they should be well defined, of great length (6,000 feet) and should recur underneath one another in depth. The laws governing the occurrence of pay-chutes on the fissure-veins mined at Brookfield, Caribou, Cow Bay, Oldham and Voglers Cove, appear to be the same as those observed at Leipsigate, and they should be well studied to ensure extensive and successful development. At the western end of the district several interbedded veins have also been discovered on the north and south dip, but still remain undeveloped.

5. *Caribou Lake anticline:* This anticline is well exposed at New Cornwall on Caribou lake, on the eastern side of which it is cut off by granite. From Caribou lake it runs south-westerly to the head of Big Mushamush lake and through Sucker lake to the foot of Wentzel lake on La Have river; thence it passes at La Have Branch and runs through Crooks, Wollenhaupt and Prescott lakes.

6. *Pleasant River Barrens anticline:* Begins at the granite on Eisenhauer lake, Newburn, runs south-westerly to the north of West and Rocky lakes and through the head of Church lake, and crossing La Have river one mile below Indian brook, it runs through Maders, Kaulback, Hirtles and Rhyno lakes of the West Branch of La Have, and crosses the Barrens and Upper Shingle lake of Pleasant river, where the fold develops into a very broad dome.

Pleasant River Barrens gold district.

Several promising, gold-bearing, interbedded veins have been developed on the north-east and south-east portions of the dome in the so-called gold district of Pleasant River Barrens, and rich ore has lately been developed, but no important mining operations have yet been undertaken on any of the leads discovered.

7. *Ohio River anticline:* The most northerly anticline has not yet been well determined, as the surveys are not completed. It occurs a short distance north of Hirtles stillwater on the head-waters of the North Branch of La Have river and crosses the Ohio river about three miles north of the New Germany and Pleasant river main road. At Mosers Corner and Meisners Settlement it is cut by a southern expansion of the main granite mass which underlies the region to the north.

Several cross-country faults have disturbed the continuity of these seven upheavals, but more detailed work is required to locate them.

Gold Districts Surveyed.

Gold districts surveyed.

My own work in the field was confined chiefly to a closer study of the structure of several gold-mining districts in the counties of Guysborough and Halifax. The first part of the summer until the 11th of August, was spent in making detailed surveys of the gold districts of Isaacs Harbour, Cochran Hill and Wine Harbour in Guysborough county and of Harrigan Cove and Beaver Dam in Halifax county, with a view to preparing special large scale plans of these districts. The surveys were for the most part plotted in the field and the plans will be completed for publication this winter.

Some preliminary notes may be here given on these districts, relating to the character of the auriferous veins already worked and their intimate relation to the structure of the anticlinal upheavals, with some conclusions on the zones of special enrichment and the possibility of developing a succession of new workable veins, similar to those mined at Bendigo, Australia, to a depth of 4,000 feet.

Isaacs Harbour Gold District.

The provincial department of mines has grouped under the name of Stormont District, the gold districts of Isaacs Harbour, Richardson (Upper Seal Harbour), Country Harbour Narrows and Forest Hill, spread over a tract 75 square miles in extent. Of these, Isaacs Harbour has been the most worked. It is situated on Isaacs Harbour, on the Atlantic coast at a distance of 50 miles to the south of Antigonish, a station on the Intercolonial railway, and it extends westward to Country Harbour and eastward to Seal Harbour.

Isaacs Harbour gold district.

Three weeks were spent making a special plan of the gold district of Isaacs Harbour, on the scale of 500 feet to an inch and it has since been completed. It covers an area of two miles and a half long by one mile and a third wide, extending on the east side of the harbour from Victoria mine to Bettys cove and on the west side from Peter Sinclair's hotel to Ragged point.

The plan comprises all the auriferous veins discovered on both sides of the harbour. On the eastern side of the harbour it includes the Victoria, Goldfinch, Mulgrave, Skunk-den, Hurricane Point and Dung Cove mines, and on the western side, the North Star and Burke mines. It does not comprise, however, the Richardson and Doliver Mountain mines, now extensively worked, which are situated two miles and a half farther north on the Upper Seal Harbour anticline crossing Isaacs harbour at its head, a special plan of which was published in 1897.

The rocks underlying the area covered by the plan are the quartzose-sandstones, called 'whin,' and interstratified slates forming the lower division of the Lower Cambrian gold-bearing series of Nova Scotia.

These rocks have been plicated into three main anticlinal folds running parallel in an easterly and westerly direction across Isaacs harbour. They have been called the north, middle and south anticlines of Isaacs harbour.

Three anticlines.

All the veins discovered in the district are interbedded veins formed during the process of folding along the stratification planes on the arch-core or limbs of these three anticlinal folds.

The original structure of the folds has been much disturbed transversely by a great dislocation coming from the north-west and followthe North-west Branch brook to the head of the harbour, as shown on the published plan of Upper Seal Harbour. From the head of

Faults.

the harbour it runs S. 15° E. (magnetic) and passes between Hurricane Point and the eastern shore and through Webb cove and Dung Cove, giving a horizontal, left-hand throw of some 1,200 feet to the north on each of the three anticlines. Several minor faults have also been determined, branching off in a north-easterly direction from the main harbour fault.

Doliver Mountain fault.

Recent developments, made by Mr. G. J. Partington on the Doliver Mountain property, have proved that one of these faults is farther east than indicated on the published plan of Upper Seal Harbour gold district. It has a horizontal throw of some 400 feet and follows, very probably, the course of the Davidson brook, in a south-westerly direction, to the harbour where it joins the main harbour fault.

The three upheavals are best observed along the western shore of Isaacs harbour, where a continuous section of the strata is well exposed from Holly point to Ragged point.

North anticline North Star mine.

Isaacs Harbour north anticline.—This anticline is well defined at the North Star mine where mining developments show the Grant, Saddle, Little Saddle, McPherson and Burke leads to curve inside and underneath one another on the arch-core of the anticlinal fold and pitch to the west at an angle of 18° from the horizon. On the north leg, the strata dip north at angles increasing gradually, from 45° on the Grant and Burke leads to 75° at Holly point; while on the south leg the dip increases abruptly to 75°, flattens again and curves in the synclinal fold of the North Star lead, 120 feet south of the anticline.

In depth, the axis-plane of the folds dips about vertically.

Hurricane Point mine.

The course of the anticline is N. 56°. W. (magnetic), and that of the syncline is N. 59° W., the folds converging eastward under the harbour; and, at Hurricane point, they are only 12 feet apart and form a crumple very favourable to the development of rich auriferous veins conformable with the strata, one of which, the Hurricane Point lead, crops out at the surface and has already been much worked and yielded handsomely. Immediately east of Hurricane point, the crumple is cut off by the main harbour fault and thrown north some 1,200 feet; it shows on the eastern shore where it developes rich rolls on the Mulgrave leads.

Rich saddle-veins.

It is noteworthy, that all the veins cropping at the surface along this crumple have proved rich, although sometimes too small to be worked profitably. The North Star lead has been mined on the western pitch of the north limb of the synclinal fold to a depth of 492 feet,

while the others were worked on the western pitch of the anticlinal fold, viz: the Saddle lead 180 feet, the McPherson lead 120 feet, the Burke lead 258 feet, while the Hurricane Point, the North Mulgrave and the Mulgrave leads have been mined respectively 430, 400 and 2,200 feet in length and 160, 190 and 220 feet in depth

The mining developments at the surface show that the paying portions of the veins are of great length and well defined, and that they are confined to the crumple, along which they form a rich zone which has been proved to extend from the North Star lead to the Mulgrave, a length of about one mile and a quarter. Deep mining.

In depth, the zone of special enrichment extends likewise along the nearly vertical axis-plane of the fold and form a succession of rich superimposed crumples and rolls to great depth.

No mining has yet been undertaken to develop this succession of crumples and rolls in depth. Encouraged by information received from this department, the Hurricane Point company made an attempt, two years ago, to develop a crumpling underneath the one they had already worked so successfully on the Hurricane Point lead, but at the depth of 170 feet operations were, unfortunately, discontinued just as the crumple was being reached and the vein was improving in size and value. Vertical shaft.

All the facts show conclusively that this anticlinal and synclinal system of pay-chutes offers a great field for deep mining by means of vertical shafts. Thus a vertical shaft sunk on the anticline near the Burke lead would probably cut a succession of superimposed saddle-veins of payable values, and cross-cuts driven 100 feet south at different levels would develop inverted, auriferous saddle-veins, on the synclinal fold, pitching west 18° and outcropping eastward under the harbour. The Hurricane Point lead would be cut at the approximate depth of 650 feet. Likewise, a vertical shaft sunk on the anticline at Hurricane point would cut a succession of crumples similar to and probably as rich as that mined by the Hurricane Point Company. Mulgrave mine.

On the east side of the harbour a very rich pay-chute or roll, pitching westerly under an angle of 12°, was extensively worked on the Mulgrave lead for a length of 1,200 feet and a maximum depth of 210 feet. This pay-chute is undoubtedly the eastern extension of one of the superimposed rolls of the Hurricane Point flexure thrown this far north by the harbour fault.

The axis-plane of the flexure runs here horizontally S. 58° E. and dips about vertically, while the interstratified veins run S. 63° E. and

dip north 62°. Large rolls of auriferous quartz were formed along the intersection of the veins with the axis-plane of the flexure, pitching westerly 12°. The rich roll worked on the Mulgrave lead is one of these and it should extend westerly beyond the actual workings to the harbour fault and be succeeded vertically by other rolls underneath one another on the veins outcropping to the south of the Mulgrave lead. This system of rolls offers great possibilities for deep mining if properly developed. It can be best developed by means of a vertical shaft and cross-cuts, or by sinking a shaft on the Mulgrave lead, below the pay-chute already worked and cross-cutting south at different levels.

Victoria mine.

At the Victoria mine, on the eastern shore of the harbour and 1,500 feet to the north of the Mulgrave, a roll of auriferous quartz, reported to be ten feet thick and pitching east 35°, has been worked for some 200 feet in length and 105 feet deep. At the Goldfinch mine, 2,100 feet to the south-east of the Victoria mine and 1,380 feet to the north of the Mulgrave lead, a roll of paying quartz, 12 inches thick and pitching east 15°, was mined 300 feet in length and 90 feet deep. It is remarkable that these two rolls, as well as the auriferous drift found on the shore to the north-west of the Victoria and 1,500 feet to the south-east of the Goldfinch mine, are all situated along the same line, running S. 59½° E. and parallel with the Mulgrave line of pay-rolls, but with the difference that on the latter the rolls pitch westward. As the strata strike S. 65° E., the Victoria-Goldfinch line of rolls intersects them at a slight angle, and probably forms a succession of auriferous rolls occurring on certain belts towards the south-east which might prove productive if developed.

Goldfinch mine.

Fault.

A left-hand fault was located on lot 18, block 2, eastern division. It runs down the Dung Cove brook S. 37° W. to the salt water pond, where it intersects the main harbour fault, and gives a horizontial throw of 130 feet north on the Mulgrave lead and about 250 feet on the Mundic lead which corresponds to the Skunk-den lead.

Undeveloped veins.

The rich float found to the east of this fault and south of the Mulgrave lead is derived undoubtedly from rolls formed on the Bliss, Slate or other leads at their intersection with the eastern extension of the flexure, and developments should therefore be undertaken in this direction.

Middle anticline.

Middle anticline.—The middle anticline could not be located as well as the north, because the rocks are concealed and developments have not yet been sufficient along its course.

On the western side of the harbour it occurs 500 feet south of the lighthouse, where it is concealed by a sand beach and salt water pond,

and it extends westerly to Country harbour, covered by drift showing debris of gold-bearing quartz.

It runs easterly across the harbour into Sculpin cove, immediately north of Salmon rock, and extends to the main harbour fault, where it is thrown north some 1,200 feet; beyond this, it runs south of east, 550 feet south of the Barry lead, to the Dung Cove brook fault, where it is thrown north 250 feet, and resumes its course towards the head of Crane pond on Bettys brook.

This fold is broad, both limbs dipping at angles increasing gradually to 65° on the north and 55° on the south. The developments have not yet been sufficient to determine the zones of special enrichment, but rich float found along its course proves the occurrence of payable veins. The structure of the fold shows that a zone of such veins will probably be found on both limbs, but at some distance from the axis, where the angle of dip is over 50°.

Shunk-den mine.

The only important leads developed are situated 700 feet north of the axis, at the Skunk-den mine, where a pay-chute dipping east 18° was worked on the Mundic lead for a length of 700 feet and a depth of 120 feet. A large block of rich quartz was discovered immediately south of the Mundic lead, but the vein from which it came has not yet been discovered.

Rich veins along synclinal fold.

On the east side of the main harbour-fault and about 1,100 feet south of the middle anticline, a rich belt of leads, called Hattie belt, 21 feet wide, was worked many years ago, by open-cut on the Gisborne property for a length of 360 feet and a depth of 110 feet and more recently on the Griffin property, and it was uncovered eastward beyond a 50-foot fault for 1,400 feet. The leads are conformable with the strata and dip south 55° to the depth of 110 feet, where they curve rapidly and the quartz pinches out in a synclinal fold, to the south of which the strata are shown in a cross-cut to dip north at a low angle with little or no quartz. The quartz was reported exceedingly rich on the north limb of the synclinal trough.

Red Head gold drift.

Very rich float was found to the south of this belt and a great deal of prospecting was done by David Buckley and others to locate the veins, but without success. Doubtless the float comes from another rich vein in the synclinal trough, superimposed to and to the south of the Hattie belt. Likewise, the rich drift found on Red head is derived probably from the north limb of the synclinal fold, thrown this far south by the main harbour fault, possibly in the vicinity of the McMillan and other belts of lead cut along Sand cove. This is one of

the few instances in which rich veins have been observed to occur in a synclinal fold in Nova Scotia, but in Bendigo, Australia, such veins have been mined in a few cases.

To develop these synclinal veins successfully vertical shafts might be sunk along the axis of the trough. A succession of superimposed V-shape veins would thus be cut through which should be especially rich on the south dip.

South anticline.

South anticline.—The Isaacs harbour south anticline is well exposed at Ragged or Bear Trap point, and for about one mile farther west along the shore of Country harbour, where a few cross-veins have been observed. On the eastern side of the harbour, it passes at the south end or a little to the south of Red head, and some of the auriferous debris washed in from the sea may possibly come from veins situated on this fold, if not from the above mentioned synclinal fold.

East of Dung cove, the anticline is thrown north about 1,000 feet by the main harbour-fault, and it crosses the road at a sharp turn where David Buckley has developed a flat lead dipping north and south on the apex of the fold. Its extension eastward is heavily covered with drift. Auriferous drift and a few veins are reported to have been discovered at Bettys cove, to the south of this anticline.

Seal Harbour rich drift.

A great deal of prospecting has been done two miles east of Isaacs harbour, along a line of extraordinary rich drift, running south $2\frac{1}{2}^{\circ}$ east towards the eastern side of Crook cove. It is believed that the drift comes from the intersection of a cross-country vein with certain belts or interbedded veins which are especially well mineralized and are possibly the eastern extension of some anticlinal system of veins.

The total production of the Stormont district given in the official returns of the Provincial department of mines from 1862 to 1901 inclusive, is 245,409 tons crushed, yielded 78,750 ounces, valued at $1,496,266, average yield per ton $6.10. Of this, probably one half and the richest ore was produced by the Isaacs Harbour mines, the Richardson mine having mostly given low grade ore.

Every mine in the Isaacs Harbour district is now abandoned, but important developments are in contemplation.

Cochran Hill Gold District.

Cochran Hill anticline.

The gold district of Cochran Hill is situated in Guysborough county, on the east side of St. Marys river, ten miles north of the town of Sherbrooke and thirty miles south of Antigonish, by the coach road.

One week was spent surveying the structure of the formation and a plan has since been prepared on the scale of 500 feet to an inch, which is now ready for publication. It includes Crows Nest and Cochran Hill mines which are nearly two miles apart on the same anticlinal fold.

This fold is the sharpest one known in the province and is much inverted to the south, the north limb dipping north 60° while the south limb is overturned and dips north 75°. The axis-plane of the fold should thus dip northerly at an angle of 68°.

The general course of the anticline at the surface is S. 82° 45′ E. (magnetic) and it pitches west at an angle of about 15° or 20°.

At the Crows Nest mine the anticline was located at a bluff of rock situated immediately east of the mine's road, and half-way between the mill and the manager's house, on area 916, block 75. It was traced eastward, up a steep cliff, across Cochran hill and the main coach road, to Cochran Hill mine, where it passes at the south corner of the quartz-mill and is well exposed 400 feet further on area 486, block 77.

The rocks brought up by the upheaval are the quartzose-sandstones and slates of the lower division of the gold-bearing series. The rocks have been subjected to such great pressure that they have become highly schistose and crystalline, holding fine crystals of staurolite, andalusite, garnet and mica. The cleavage is highly developed, while the bedding plane is almost completely obliterated, and, consequently, the structure of the anticlinal fold is very difficult to make out.

Crows Nest mine.

All the gold-bearing veins operated at both mines follow the stratification plane. A few quartz veins holding mica are also met with, especially at the Crows Nest mine, but they generally follow the cleavage plane and invariably cut the bedded veins when they meet. Quartz mined from one of these at the Crows Nest mine is reported to have yielded a little gold, but it is more likely that the gold came from the encasing slate belt which holds also an auriferous vein—the Belt lead. These micaceous veins are offshoots from granitic dykes occurring in the vicinity and of later origin than the auriferous bedded veins.

At the Crows Nest mine, the Stake, Rose and Belt leads have been worked by different companies, and more recently by the Old Provincial Mining company, for a maximum length of 850 feet and a depth of 100 feet. These leads occur within a width of 60 feet and at an average distance of 200 feet to the south of the anticline.

Cochran Hill mine.

At the Cochran Hill mine a large belt of leads, called the Mitchell belt, and a few other adjacent leads, have been mined from time to time. They are situated at a distance of 300 feet to the south of the anticline. The maximum depth attained is 125 feet on the Ross lead and surface developments have been extended over 1,800 feet in length.

The Mitchell belt is 75 feet wide and contains interbedded veins from two to twelve inches wide. It is considered a low grade deposit which could be operated profitably.

Zone of auriferous veins.

The present developments indicate that the relative position of the gold-bearing leads with reference to the anticline is the same at both mines; that the zone of auriferous veins runs nearly parallel with the anticline, at a distance of 200 feet at Crows Nest mine and 300 feet at Cochran Hill mine to the south of the axis, and that systematic developments along this zone between the two mines will probably uncover new gold-bearing veins.

In depth, the pay-chutes dip westerly, parallel with the pitch of the fold, and they probably also recur on the different adjacent veins, towards the north, in a plane parallel with the axis-plane of the fold which dips north at an angle of 68°. Developments and cross-cuts have therefore to be directed towards the north as greater depth is attained.

The rich pay-chutes worked at the Crows Nest mine, on the Stake and Belt leads pitch westerly at an angle of 15° to 20°. Both streaks have been worked out to a fault running south easterly, beyond which they have not been discovered. To find their continuation on the west side of the fault, the extent of the downthrow and horizontal-throw of the fault has to be established. Unfortunately, this could not be exactly determined from the developements made along the fault. The location of the anticline on both sides of the fault shows that it has been thrown to the left for about 50 or 75 feet. The horizontal throw of the leads is probably about the same.

A 20-stamp mill with one Wilfley table has recently been built by the Old Provincial Mining company at the Crows Nest mine, and, at the Cochran Hill mine a 20-stamp mill with two Wilfley tables was newly put in.

In the official returns of the Department of Mines for 1901, the total production of Cochran Hill is incorporated with that of Goldenville, under the title of Sherbrooke district: 264,131 tons of ore crushed yielded 148,477 ounces of gold, valued at $2,821,068, average yield per ton $10.68.

Wine Harbour Gold District.

The gold district of Wine Harbour is situated in Guysborough county, on the Atlantic coast, 16 miles south of the town of Sherbrooke and 56 miles from Antigonish. Wine Harbour gold district.

Three weeks were spent in surveying the district and plotting a plan on the scale of 400 feet to one inch, to include the whole area under development, two miles long by three-quarters of a mile wide.

The area is underlaid by the quartzose-sandstones, or 'whin,' and the slates of the lower division of the Lower Cambrian gold-bearing series of Nova Scotia.

The measures have been flexed into two anticlinal and one intervening synclinal folds converging towards the west.

The most northerly anticline has been determined on lot 388, block 6, immediately south of Rocky point on Indian harbour, where the rocks dip at low angles increasing gradually, northward to 75° at Fleming cliff, and southward to 45°. It runs N. 74° W. and converges westward with the synclinal, the two joining at a point about 900 feet north of the Major Norton workings, where the strata are exposed laying almost horizontal near the dome of the southern anticlinal fold. A few veins were observed along the shore, 800 feet north of Rocky Point, but none have so far been developed on this fold. North anticline.

The synclinal trough occurs between the two anticlines. From the northern extremity of Barachois pond, it runs westerly, passes 150 feet to the north of the old site of Eureka mill, and ends at its junction with the north anticline. Syncline.

On area 140, block 6, a belt of promising quartz rolls in slate was uncovered in the synclinal trough, which pitches eastward at a low angle, and others probably occur along its course which might prove productive if developed.

The south anticline crosses the south end of Barachois pond, runs westerly N. 65° W. under the boulder clay of Rude hill, passes 100 feet south of the old site of Eureka mill, follows Barachois brook and outcrops at the surface on area 36, block 41, at a distance of 750 feet north of the Major Norton workings, beyond which it is heavily covered with drift and runs westward N. 63° W., passing a short distance north of the Smelt Brook cove of Wine harbour and at the south end of Lake Cooper where it is well exposed. Wine Harbour anticline.

The south anticline may be considered the main anticline of the district, while the other anticline and the syncline form a subordinate crumple on the north limb of the former.

The north limb on the Wine Harbour anticlinal fold dips north 50° or 60°, while on the south limb the dip increases abruptly to 70°, then gradually to 85°. It pitches easterly at a low angle diminishing towards the west and it forms a dome at the western end of the district which could not be exactly determined as the rocks are concealed.

No leads have yet been discovered on the north limb. All the veins operated and developed in the district occur on the south limb along which they were deposited in fissures following the stratification planes during the process of folding of the measures.

The productive veins have been operated over a maximum length of one mile and a half and a width of 1,600 feet and dip south from 70° to 80°. On several of them very rich pay-chutes have been worked, all of which pitch eastward, like the anticlinal fold, excepting possibly the pay-chute worked on the Eureka lead, which may dip westerly for some local cause.

The present developments show that the paying portions of the veins occur along three well-defined lines or zones, closely related to the general structure of the district, which may be called the eastern, middle and western pay-zones.

Eastern pay-zone Barachois mine.

At the Barachois mine, at the eastern end of the district, a well defined zone of auriferous veins occurs between 200 and 300 feet to the south of the anticline, and pay-chutes pitching east have already been profitably worked on the Romkey, Twin and Hamilton leads. The pay-chute on the Romkey was worked 1,000 feet in length and 200 feet in depth. The leads curve gently eastward towards the anticline and extend to the north end of Barachois island.

Several other veins, some of large size, have been uncovered to the north and south of this belt. They should be developed further west, along the pay-zone extending westward, across Rudehill hand Barachois brook, towards Eureka mine. The extraordinarily rich float, found along the shore at Doody head, has undoubtedly drifted from this zone, the direction of the drift being S. 9° E.

Eureka mine.

At a distance of 2,500 feet west of the Barachois mine on the eastern pay-zone and 500 feet south of the anticline, the Eureka lead has been worked 500 feet in length and 210 feet deep.

Between the Eureka and the Hattie-Mitchell workings there is a length of 2,250 feet of promising ground along the pay-zone, which being covered with drift, is wholly undeveloped, but should also be prospected. Rich float has been found along this zone on area 11, block I, on the Old Provincial Mining company's property, which should be traced to its source.

A rich pay-chute pitching east was operated for 800 feet in length and 240 feet in depth on the Hattie-Mitchell belt, situated 1,000 feet to the south of the anticline; and, 150 feet farther south, the De Barres, or middle belt, was worked 800 feet in length and 80 feet in depth.

The measures have been much disturbed in this vicinity by a series of faults radiating towards the south and south-east and crossing the Major Norton, Creighton, Hog, Halliday, Hattie-Mitchell, De Barres, Washington, Air-shaft, Plough and Caledonia leads. All these leads have been proved to be auriferous and worked more or less along a zone extending also towards the south. This zone of pay-veins and the faults have probably been caused by stresses developed towards the south by the meeting of the north anticlinal and synclinal folds. Faults. Middle pay-zone.

The heaviest fault has been well determined by Mr. Matthew McGrath's development works on the Plough lead belt, showing a horizontal throw of 130 feet to the north and a down-throw of 57 feet, on the east side. Plough lead.

A pay-chute of quartz, 18 feet wide, pitching east 16°, has been extensively worked and developed on the Plough lead belt across three properties for a length of 1,150 feet and a maximum depth of 352 feet. The chute is formed by numerous quartz anglers of fissures dipping south into the Plough lead belt.

These anglers appear to extend to the south-east and north-west across the formation and constitute a zone of special enrichment on the Moore, Caledonia, Plough, Wiscassett, Washington, McKenzie, Gillis and Mundic leads which have been more or less worked. All the pay-chutes on this zone pitch eastward. Western pay zone.

A very rich and regular pay-chute pitching east 26° has been worked on the Caledonia lead for 500 feet in length and 175 feet in depth, to a small fault, beyond which it has not yet been found. Caledonia lead.

The Moore lead has also proved rich and has been worked 400 feet in length, and 190 feet in depth. It is cut at the western end of the works by a left hand fault running north-east. Several very large belts of Moore lead.

quartz of low grade have been developed to the south of the Moore lead, and rich float has been found immediately north of it.

The Wiscassett and Washington belts have been worked, respectively, 375 and 250 feet in length and 65 and 75 feet in depth.

Mines in operation.

Three companies were operating in the district last summer. The Plough Lead Mining company were successfully working the Plough lead at the depth of 180 feet. The Old Provincial Mining company has completed a shaft 352 feet deep on the Plough lead, and is preparing to develop the pay-chute cut at that depth. L. W. Getchell & Co. were operating the large belts of quartz lying immediately south of the Moore lead, on the Napier Gold Mining company's property. Some development works were also being done on the Barachois, Eureka and Stuart properties.

Quartz-mills.

There are at present six quartz mills erected in the district: the Plough Lead Mining company's mill—15 stamps; the Old Provincial Mining company's mill—10 stamps; the Napier Gold Mining company's mill—10 stamps; the Eureka mine's mill—10 stamps; the Barachois mine's mill—10 stamps; and Dr. Eames' Crusher and roasting furnaces to extract gold and arsenic from arsenical-pyritous ores.

The total production of the Wine Harbour gold-district, from 1862 to 1901 inclusive, was 35,422 ounces of gold, from 55,335 tons of ore crushed, valued at $673,031, giving an average yield of $12.16 per ton of 2,000 lbs. In 1901, 29,664 tons crushed yielded 5,592 oz. 10 dwts. of gold.

Harrigan Cove Gold District.

Harrigan Cove Gold District.

One week was devoted to a survey of the gold district of Harrigan Cove, situated in the county of Halifax, on the Atlantic coast, at a distance from Halifax of 75 miles by water and 100 miles by the coach road. Most of the surveys have been plotted, on the scale of 400 feet to an inch, and the plan will soon be completed for publication. Meanwhile a preliminary description may be given of the general structure of the folds and veins.

A good section of the rocks is well exposed across the district along the area line dividing lot 215 from 216 on the St. Anthony property. It shows that the series have been plicated into one main anticlinal fold, on the south limb of which a subordinate crumple occurs at a distance of 1,250 feet to the south of the axis.

The main anticline was located on area 616, block 2, along a small swampy brook running eastward, at a distance of 2,000 feet north of the St. Anthony lead. The fold is broad; the angle of dip increasing gradually on both limbs until it reaches 90° half a mile north of the axis and 40° at a distance of 800 feet to the south of it. North anticline.

A few veins have been uncovered on both limbs, at some distance to the north and south of the axis, but none have yet been proved sufficiently auriferous to warrant developments, although some gold float is reported to have been found in the vicinity.

At a distance of 1,250 feet south of the main anticline the strata curve into a synclinal and, 150 feet further, into an anticlinal fold. The two folds converge towards the east and meet on area 390, beyond which the crumple terminates.

The south anticline runs N. 75½° W. and shows prominently 600 feet north of the St. Anthony lead, along a bold ridge for 1,600 feet, beyond which it is concealed by a hill of boulder clay running transversely north and south. On the north limb the strata dip 35°, while on the south the angle of dip increases gradually and reaches 60° at a distance of 1,500 feet south of the axis. South anticline.

Two left-hand faults were determined crossing the anticline: one, the St. Anthony fault, occurs on the eastern part of area 319, runs S. 25° W. across the auriferous belts, giving a displacement of 90 feet on the anticline; the other passes on area 278, where the throw is 50 feet south, runs southerly and probably meets the former fault between the St. Anthony and the A. Kent Archibald works. Several important faults undoubtedly occur to the westward, but they have not been made out yet. These faults should be kept in mind in the prosecution of surface developments and determined if possible. Faults.

All the veins discovered in the district, follow the planes of stratification and occur on the south limb of the south anticline. The area under development, and including all the veins operated, extends from the south anticline 1,600 feet southward across the stratification and and 2,800 feet east and west along the veins. Auriferous area.

Several large superimposed saddle-veins have been uncovered along the apex of the fold pitching westward at a very low angle. On the north dip they pinch out immediately north of the axis, but on the south limb they extend to a great depth, as is well proved at the surface by the cropping out of a succession of veins extending for a great distance to the south of the axis, the upper portions of which were denuded away to the present surface level. Large undeveloped veins

Some very rich float has been found south of the anticline and twelve large belts of quartz veins have recently been cut in the 600 feet of the strata between the anticline and the St. Anthony lead, most of which are well mineralized and show gold. None of them have, however, been cut yet in more than one or two places along their course, and they offer a very promising undeveloped field for the prospector.

St. Anthony mine.

The St. Anthony lead has proved so far the best producing vein of the district. A rich pay-chute pitching westerly has been worked 200 feet in depth and 500 feet in length to the St. Anthony fault, beyond which it has not yet been recovered. The throw here is to the south and probably less than the 90 feet of displacement measured on the anticline, and there should be no difficulty in finding the lead on the west side of the fault. The St. Anthony lead has been traced 1,600 feet in length east of the fault.

South of the St. Anthony lead the ground is low, swampy and wholly undeveloped.

A. Kent Archibald mine.

A great deal of development work has recently been done on the A. Kent Archibald property, situated to the west of the St. Anthony property, and over twenty-five belts of veins have already been uncovered, 300 feet south of the anticline, across 550 feet of strata. Several of the veins, well mineralized and auriferous, have been mined to limited depths. Pay-streaks or rolls pitching westerly occur in a line or zone running north-west and south-east, along which developments should be directed. One of the leads discovered last summer is especially rich in coarse gold, and the debris found along its outcropping showed very fine crystals of gold, in cubes, several of which were secured for the museum through the kindness of Mr. Monroe Archibald. They are the only crystals of gold discovered in Nova Scotia of which I am aware.

Between 400 and 600 feet farther south two large belts of leads have been mined a little on the McMann property.

Port Dufferin belt.

Some gold-bearing drift has also been found and a few veins lately prospected as far west as Port Dufferin, where this anticline crosses the Salmon river 1,300 feet above the bridge. A crumple of the strata apparently occurs a short distance below the bridge.

Moosehead mine.

East of the St. Anthony mine the country is generally covered with drift. At Moosehead, three miles east of Harrigan cove, some development work has been done from time to time on a few veins lying immediately south of the anticline.

In conclusion, it may be said that the very large field of undeveloped auriferous belts here present should draw the attention of the prospector, and that the A. Kent Archibald, St. Anthony and other adjacent properties, already proved productive, are capable of being operated on a much larger scale. It is believed that the plan which has been made will greatly assist in such developments. Conclusions.

Three mills are erected in the district, viz. :—St. Anthony Gold Mining Co.'s mill, 10 stamps; A. Kent Archibald, *et al*, 5 stamps; M. McMann and others, 5 stamps. Quartz-mills.

The gold returns reported from Harrigan cove to the Provincial department of mines, Halifax, for the year 1901, were 4,167 tons crushed, yielding 2,595 ozs. 6 dwts. 9 grs., or an average of 12 dwt. 11 grs. per ton of 2,000 lbs. The returns just received from the provincial Commissioner of Mines for the year 1902 are :— Gold production.

St. Anthony Gold Mining Co.	1,183 tons	yielded	493 ozs.
A. Kent Archibald, *et al*	1,095	"	750 ozs.
M. McMann and others.........	124	"	34 ozs.
Total	2,402	"	1,277 ozs.

Beaver Dam Gold District.

A hurried survey was made of the structure of the gold district of Beaver Dam, situated on the Killag branch of the West river of Sheet Harbour, 7 miles east of the coach road, in Halifax county. A full description of the district will, however, have to be deferred until the surveys are plotted. Beaver Dam Gold District.

All the veins discovered follow the planes of stratification along an anticlinal fold. No mining operations of any importance has yet been undertaken. A large belt of low grade ore has been developed by a shaft and cross-cut on the Jos. H. Austen, *et al*, property at the east end of the district. In a report submitted to the owners Mr. L. F. S. Holland gives the following measurements:—Shaft 98 feet deep on a belt 15 feet wide, cross-cut north 62 feet, cross-cut south 39 feet, total width of the auriferous belt 74 feet, half of which is quartz and slate giving an average value by sampling of $3.50 per ton. This belt has been uncovered 400 feet further west. Jos. H. Austin mine.

Three-quarters of a mile further west some very rich drift was found on the Geo. E. Van Buskirk and other adjoining areas, and a great number of leads, some of which are auriferous, have recently been un- Dimock and Zwicker's prospecting.

covered by Dimock and Zwicker by surface trenches cut across 785 feet of strata. The country is low, all covered with drift, and hence difficult to prospect.

The developments, though limited, have shown auriferous veins over a large area along the anticlinal fold, some of which are rich in gold and others form large deposits of low grade ore which deserve more attention than they have hitherto received.

A 10-stamp mill has been erected on the Jos. H. Austen property, and a good water-power is available on the Killag river within a short distance of the mine.

Gold Districts Examined.

A hurried examination and partial surveys were also made of recent mining developments in the gold districts of Richardson, Doliver Mountain, Goldenville, and County Harbour Narrows, in Guysborough county; of Ecum Secum, Dufferin, Fifteen-mile Stream, Caribou. Moose River, Mooseland, Tangier and Waverley, in Halifax county; of Renfrew and Mount Uniacke in Hants county. and Gold River and Leipsigate in Lunenburg county.

Deep Gold Mining.

Possibility of deep mining demonstrated by geological work.

The knowledge now gained, by a detailed study of the principal gold districts in the province, proves conclusively that the auriferous veins outcropping at the surface on the north and south limbs of the anticlinal folds are the remnants of the north and south legs of the superimposed 'saddle-veins' which once occurred at a higher level than the present surface, and demonstrates that, below, auriferous saddle-veins will be found recurring along the axis-plane of the fold. Moreover, from the analogy of the Australian gold-bearing 'saddle-reefs,' occurring in a similar manner and profitably operated to a depth of 4,000 feet, it may be inferred that the quartz veins in Nova Scotia will, in depth, be as large and as rich in gold as those outcropping at the surface.

Deep mining proved by actual practice.

It is difficult, however, to induce capitalists to invest money in extensive mining developments unless similar undertakings have already proved successful in actual practice. It is, therefore, very gratifying for me to state that the recommendations of the Geological Survey have already been put into practice at the Bluenose, Dufferin, Richardson, Doliver Mountain and other mines, and, although the developments are as yet limited, the results obtained are so satisfactory and

conclusive that they are attracting the attention of foreign engineers and capitalists and similar developments are being contemplated at other mines.

Mr. C. K. Leith, of the United States Geological Survey, and professor at the University of Wisconsin, reviewing the work of the Geological Survey of Canada in the gold-fields of Nova Scotia, says* : 'Mr. E. R. Faribault's work will be of immediate practical advantage to mining men, some of whom have already testified to its accuracy and value. It is another instance, lately of frequent occurrence, of geological work done from a purely scientific standpoint having direct economic value. From a scientific standpoint, also, the results are of interest as illustrating a principle of ore disposition. In many districts, and particularly in the Lake Superior district, it has long been known that ore deposits were partial concentrates in pitching troughs by descending waters. Van Hise has lately enunciated the principle that the openings in arches or pitching folds are favourable places for the concentration of ore deposits by *upward moving waters*. The formation of the gold-bearing veins of Nova Scotia seems likely to have occurred in this way.' Economic value of geological work in Nova Scotia.

Bluenose Mine, Goldenville.—Much credit is due to the late Mr. Simon A. Fraser for having first undertaken, and Messrs. Thos. Cantley and A. G. McNaughton for having executed so successfully at the Bluenose mine a new system of mining development on the Goldenville anticlinal fold, which should be an object lesson for the gold miners of the province, as it will, no doubt, be the inauguration of a new era of extensive and permanent deep mining. Bluenose mine Goldenville.

A detailed survey was made on October 15 last of the new developments and a transverse section was prepared which is here reproduced on a reduced scale. The section is made through the main shaft on the Springfield belt, and along two cross-cuts driven north, one above the other, at the depths of 280 and 364 feet, and at a distance of 30 feet west of the main shaft. The upper cross-cut is 230 feet and the lower 250 feet long. They show the structure of the Goldenville anticlinal fold with a subordinate small flexure on the north leg, and disclose the recurrence of large auriferous saddle-veins, from the surface to below 364 feet. Transverse section.

The saddle-veins are remarkably well developed on the apex of the fold where they attain a large size, and the legs continue downwards Recurrence of workable saddle-veins.

*The Journal of Geology, Jan.-Feb., 1900, vol. VIII, No. 1, page 84.

very regularly on both legs, the veins diminishing but little in size, more especially on the south leg, which goes to prove that they will extend to great depth, as well as parallel with the anticlinal axis.

Most of the veins developed have proved auriferous, and two of them, the McNaughton belt on the south dip and Cantley belt on the north dip, have already been profitably worked.

McNaughton belt.

The McNaughton belt measures 6 feet 8 inches in width at the upper level and 6 feet at the lower, and is composed of large irregular quartz rolls and stringers pitching westerly 15 degrees to 22 degrees in slate and a few thin layers of whin. It has been opened 300 feet in length on the upper level and 500 feet on the lower, and the greater part of the block of ore between the two levels has been extracted by backstoping. A rise of 65 feet has been made above the upper level, where the belt has widened to eight feet and ten inches and begins to curve towards a saddle higher up. The official returns of the ore extracted from the McNaughton belt for the year 1902 are 11,211 tons, yielding 2,391 ozs. of gold, which is very satisfactory considering the size of the vein.

Springfield belt.

The Springfield belt was profitably worked to a maximum depth of 400 and a length of 900 feet, and is still found auriferous at the bottom of the main shaft, which is being sunk some 50 feet deeper for a third cross-cut, to develop new saddles and backstope the McNaughton and probably other workable belts already cut. The South Springfield belt was mined 113 feet in depth and 242 feet in length.

Pay-zone on south dip.

As the McNaughton belt has been profitably mined almost to the apex of the fold, 145 feet above the lower level, we may conclude that the denuded portion of the Springfield belt, about 150 feet, was pay-ore, which added to the depth worked, 400 feet, would give a possible total depth of 550 feet of pay-ore on the south dipping veins. The McNaughton belt may, therefore, be expected to carry pay-ore for 400 feet deeper than the 364 feet level. On the south dip the zone of pay-veins is thus approximately 150 feet in width and lies immediately south of the anticlinal axis, along which it extends to great depth, unless a change should be found in the structure of the fold, of which there is so far no indication. In length the Springfield belt has been profitably worked for 900 feet, and the McNaughton belt will probably be workable for the same length.

A continuous zone of pay-veins has been worked to limited depths, all along the south limb of the Goldenville anticlinal fold, for an aggregate length of 4,400 feet, from the Springfield to the Palmerston belt,

beyond which development work has been prevented by the swampy nature of the ground. The surface developments are sufficient to prove that this zone affords a field of virgin ground, large enough for several mines like that operated by the Bluenose company, and Mr. George W. Stuart is at present sinking a shaft on area 743, seventy-five feet west of the open-cut on the Palmerston belt, in order to develop the zone of pay-veins, which has proved very rich in gold in this vicinity, by a system of cross-cuts and drifts at different levels.

The developments on the north dip at the Bluenose mine, have not yet been sufficient to determine the pay-zone, but on the Cantley belt they show that the workable portions of the veins are restricted to certain parts of the subordinate flexure occuring on the north limb of the main anticline, and further developments will no doubt determine some well-defined zones of pay-chutes pitching, like the flexure, easterly 20 degrees. Pay-zone on north dip.

The most regular and continuous pay-chutes worked in Goldenville were operated on the north limb of the anticline. In the plan and report of that district, published in 1897, three zones of pay-chutes are given: the Wellington, Hayden and McRae lines of pay-chutes. In the Summary Report for the same year, page 109, referring to the Hayden line of pay-chutes, I said, 'A swamp lying north-west of the Little Hayden has, no doubt, prevented prospecting further north-west on this undulation, but there is every reason to believe that rich streaks occur there.' It is gratifying to learn that this prediction has been fulfilled and that several rich pay-chutes have since been developed with a great deal of skill by Mr. Wm. McIntosh, the superintendent of the Royal Oak mine, and for the year 1902, 4,310 tons of ore extracted have yielded 2,394 ozs. 16 dwts. of gold. Royal Oak mine.

Salmon River Gold District—Dufferin Mine.

A general description of the mining developments on the arch-core of the anticlinal fold at the Dufferin mine. has already been given in the Summary Report for 1899, page 183, and a transverse section showing the structure of the saddle-veins is now ready for publication. Saddle-veins developed by vertical shaft and cross-cuts.

This section shows that a vertical shaft 420 feet deep with cross-cuts through the anticlinal fold at 134, 200, 315 and 420 feet levels have developed a succession of superimposed saddle-veins, which do not crop at the surface, five of which have been worked between the surface and the 315 feet level.

This mine has been one of the best gold producers in the province: 117,906 tons of ore treated having yielded 41,497 ozs. 5 dwts. 20 grs.

of gold valued at $788,448, giving an average of 5 dwts. 20 grs. per ton of 2,000 lbs. Through one cause or another, the mine is at present idle, but will undoubtedly be taken in charge again by some skilful mining engineer and operated as successfully as before, which has been the case with several other abandoned mines lately reopened.

Upper Isaacs Harbour Gold District.

Upper Issacs Harbour.

A special plan of this district, also called Upper Seal Harbour, was made in 1897 and descriptive notes were published in the Summary Report for that year, in which it was pointed out, at page 106, that 'Large belts of low-grade ore, conforming with and similar to that of the Richardson vein, certainly occur along this fold, but they will only be found on the apex of the fold, along which more prospecting should be done; and this could be accomplished most readily and at least cost by sinking vertical shafts along its axis.' This recommend ation has since been successfully put into practice at the Richardson and Doliver Mountain mines.

Richardson mine saddle-veins.

Richardson Mine.—At the Richardson mine a vertical shaft was sunk 160 feet in depth, about 900 feet to the eastward of the Richardson vein, intersecting at the depth of about 100 feet the south leg of an overlying saddle-vein giving ten feet of quartz and slate, which was developed by a drift 60 feet eastward and a cross-cut 84 feet long to the north leg which shows six feet of ore. The character of the ore and structure of the saddle-vein are identical with those of the Richardson; but for some cause, the work of sinking has been stopped. The property, however, has been acquired by a strong American company which contemplates important mining developments, by means of a vertical shaft and cross-cuts and with up-to-date equipment; and alterations are already in progress. The large cyanide plant lately erected is to be utilized for a new process of gold extraction, and the 60-stamp mill improved and twenty more stamps added. The production to date from this district shows 73,314 ounces of gold from 226, 355 tons of ore treated.

Vertical shaft intersects large saddle-veins.

Doliver Mountain Mine.—At Doliver mountain, on the same anticline and one mile west of the Richardson mine, Mr. G. J. Partington has, during the last two years, developed in a very skilful manner a succession of large saddle-veins similar to the Richardson. The exact position and direction of the anticline and the structure and value of three superimposed saddle-veins outcropping at the surface were first ascertained. These are the Howard, Forge and Partington saddle-veins, measuring respectively 10, 30 and 33 feet vertically on the apex,

the former pitching eastward 12° and the latter 16°. A vertical shaft, 17 ft. 6 in. x 5 ft. 3 in., was then sunk on the anticline, on area 774, about 400 eastward of the cropping of the Partington belt, to intersect the three saddle-veins as well as others underlying at their apex. After going through 55 feet of quicksand, small veins were intersected at depths of 55, 92 and 102 feet, which, although not apparently of workable size, proved the shaft to be exactly on the apex of the fold.

At the depth of 130 feet the Partington belt was intersected. It is being developed on the north and south legs and has yielded about 6,000 tons of ore, highly mineralized, composedof rolls, bunches and stringers of quartz running through a belt of slate and much resembling that of the Richardson mine. Below the Partington saddle-vein the shaft cut through a very hard bed of quartzose-sandstone or whin, 29 feet thick, then at the dept of 192 feet another saddle, was intersected 22 feet thick, well mineralized and composed of two distinct corrugated lodes and a network of irregular feeders of quartz running through the slate belt. The shaft is now 190 feet deep, but the company will wisely continue the sinking without interruption until the depth of 1,000 feet has been reached. It will thus intersect successively the Forge and Howard belts, already uncovered at the surface, and, no doubt, other new underlying saddle-veins, on the apex of the fold, where they are of greater size and value.

These operations are well worth recording, as the first instance in Nova Scotia where a series of saddle-veins has been systematically developed with due regard to its geological structure and a proper knowldege of its possibilities for extensive and permanent mining. The company is erecting a large, modern plant. A fine water-power is being utilized at the head of tide on Isaacs Harbour river, capable of generating 750 horse power. Thepower is transmitted by electricity to the mine, where an electrical host and fifteen-drill air compressor have been installed, and an eighty-stamp mill in which 40 stamps are to be used at once. Large water-power plant and mill.

This is certainly one of the best equiped mines to operate large bodies of low-grade ore at a low cost, and it only requires a good plant for the extraction of gold from the sulphides to make it the model gold mine of the province. What has been accomplished at this mine can also be done at several points along the Upper Isaacs Harbour anticlinal fold and in many other districts where the conditions are favourable, particularly Isaacs Harbour, Goldenville, Salmon River, Mooseland, Tangier, Oldham, Waverley, Fifteen-mile Stream, Renfrew, etc. Model plant.

Methods of Deep Gold Mining.

Deep mining at Bendigo.

At Bendigo, Australia, the systems of saddle-reefs are being developed in depth by means of vertical shafts sunk on the anticlines, and a succession of cross-cuts and drifts at about every hundred feet. It is, therefore, very desirable that the vast experience gained in that field should be taken advantage of by those contemplating the development of our Nova Scotia systems of saddle-veins. Much practical information may be obtained from the official reports of the Victoria department of mines at Melbourne, and other literature published on the subject in the transactions of the Australian mining and scientific societies.

Location of vertical shafts.

The success of deep mining depends above all on the proper location of the vertical shafts, and this can only be done after a careful study of the structure and conditions peculiar to each district. Some districts are especially suitable for such developments, while others are not, although they may have proved good gold producers over a large area. Second in importance to the location of the shafts, is the direction and length of the cross-cuts and drifts to intersect the pay-veins.

Vertical and inclined folds.

In the case of anticlinal folds, where axis-plane is vertical, like that of Upper Isaacs Harbour, Mooseland, Tangier, Dufferin and Oldham, a vertical shaft would run parallel with it; but if the axis-plane dips at an angle from the vertical, as at Goldenville, Fifteen-mile Stream, Waverley and Renfrew, the vertical shaft would necessarily approach or recede from the axis as it is sank to greater depth, according to its position with reference to the axis. In the first case, very little cross-cutting would be necessary, if the shaft is properly located as it would keep in the pay-zone all the way down; but in the latter case, the deeper the shaft the more cross-cutting will have to be done. The dip of the anticlinal axis has thus to be taken into consideration in locating a vertical shaft, so that unnecessary cross-cutting may be avoided.

Testing of the veins.

The veins intersected should be carefully sampled and separate mill-tests made of the most promising, to determine the workable portions and pay-chutes. It is very desirable that the structure of the strata and veins intersected should be recorded on a large scale plan, before it is concealed by the timbering of the shaft. A complete set of underground plans and sections should also be kept of cross-cuts, drifts, winzes, rises, etc., showing the value, size and structure of the veins opened up. Such plans would show the distribution of the ore-bodies in the area developed and assist in defining the direction and extent of the pay-zone and in laying out the development works.

Advantage should be taken of the fine water-powers which are lying idle in close proximity to most of our mines, now that gold mining is being established in the province on a more permanent footing, as they would greatly lessen the cost of operation. The transmission of power by compressed air for short distances and by electricity for longer distances has proved to be practicable and is extensively and successfully used outside of the province. Water-powers.

Chemistry and Mineralogy.

Dr. G. C. Hoffmann.

Reporting on the work done in these branches of the Survey's operations, Dr. Hoffmann says:—'The work carried out in the chemical laboratory during the past year' has been, in pursuance of the practice of former years, almost exclusively confined to the examination of such minerals, ores, etc., as were considered likely to prove of more or less economic value and importance. Briefly summarized this work included: Summary of analyses made.

'1. Analyses of fuels, namely—of peat, from the thirty-fourth lot of the sixth concession of the township of Lancaster, Glengarry county, province of Ontario; and from a point some sixty-seven miles up from the mouth of the Kwataboahegan, a tributary of the Moose, in the same province. Of lignite, from Lepine creek, a stream flowing into Rock creek—which is a tributary of the Klondike, Yukon territory. Of lignitic coal, from near the head of Kettle river, Yale district, in the province of British Columbia. Of coal, said to occur near White Horse, Yukon territory; and from near the head of Kettle river, Yale district, in the province of British Columbia. Of semi-anthracite, from near Blairmore, district of Alberta, and of anthracite, stated to have come from near White Horse, Yukon territory. Mineral fuels.

'2. Analyses, more or less partial, of iron ores from, among other localities,—The farm of John Hatley, Cleveland, Annapolis county, and from Georges river, Cape Breton county, in the Province of Nova Scotia. The first lot of the eighth range of the township of Wolfstown, county of Wolfe; and from Chicoutimi county, in the province of Quebec. The fifteenth lot of the fifth concession of the township of Oso, Frontenac county; the thirty-first lot of the twelfth concession of Grattan, Renfrew county; from near Flying Post, Mattagami river, district of Algoma; and from south of Waboose lake, same district, in the province of Ontario. From a deposit on Sutton Mill lake, west side of Iron ores.

James Bay, near Cape Henrietta Maria, in the district of Keewatin; and from Port Kells, on the south side of the Fraser, district of New Westminster, in the province of British Columbia.

Nickel ores.

'3. Analyses, in regard to nickel content, of pyrrhotite from the following localities:—In the province of Ontario, from the seventeenth lot of the second concession of the township of Westmeath, in Renfrew county; the tenth lot of the fourth concession of the township of Olden, in Frontenac county; from a cutting on the Whitney and Opeongo Railway, about seven miles and a quarter from its junction with the Canada Atlantic Railway, township of Sproule, in the Nipissing district; from the eighth lot of the fourth concession of the township of Dowling, and from the fourth lot of the fourth concession of the township of Graham, both in the district of Algoma. In the province of British Columbia, from a mountain on the west side of Ice river, about six miles from the forks of Ice and Beaverfoot rivers, in the East Kootenay district; the north bank of the Thompson, about five miles above Lytton, as likewise from Shuswap lake, in Yale district. Analyses were also made of specimens of this mineral from the fourteenth lot of the fifth range of the township of Masham, Ottawa county, in the province of Quebec; and from about a quarter of a mile north of Boularderie Centre, Victoria county, in the province of Nova Scotia.

Gold and silver.

'4. Assays of numerous samples of material for gold and silver from localities in the provinces of Quebec and Ontario; the district of Keewatin; the Yukon territory; the districts of East and West Kootenay, Yale, Lillooet, Cassiar, New Westminster, and from Vancouver island, in the province of British Columbia.

Limestone and dolomite.

'5 Analyses, complete or partial, of limestones and dolomites (in continuation of the series of analyses of such stones already carried out, in connection with an inquiry into their individual merits for structural purposes, for the manufacture of lime, or of hydraulic cement, or for metallurgical purposes, etc.), including, that of a dolomite from Brookville, St. John county, province of New Brunswick; of limestone from the Archambault quarry, on the twenty-sixth lot of the seventh range of the township of Weedon, Wolfe county, province of Quebec; of a limestone from a quarry on the thirty-fourth lot of concession A of Ottawa Front, township of Nepean, Carleton county; and of a dolomite from Walkerton, Bruce county, in the province of Ontario.

Natural waters.

'6. Analyses of natural waters—with the object of ascertaining their suitability for economic or technical purposes, or possible value

from a medicinal point of view—from the undermentioned localities:—From a spring on lot 1 of the 1st concsssion of the township of Scarborough, York county, and from a well in the village of St. Joseph, Huron county, in the province of Ontario; from a spring about four miles back from the west bank of the Fraser, nearly opposite the mouth of Big Bar creek, Lillooet district, and from a spring at Chilcotin, about twenty-three miles from Chimney creek ferry, Cariboo district, in the province of British Columbia.

'7. Analyses of several minerals of economic value, some of which had not previously been recognized as occurring in Canada, and of others, from localities where they were not previously known to occur, as for instance:—1. Of chrompicotite, a variety of chromite, or chromic iron, which has been met with in considerable quantity on Scottie creek, some seven miles east of Mundorff, in the district of Lillooet, province of British Columbia. This mineral had hitherto been found in but one locality, namely, at Dun Mountain, in New Zealand. The find may prove to be of considerable commercial value, as a source of chromium, which is used, among other purposes, in the manufacture of bichromate of potash, a preparation employed for calico-printing and in certain forms of electric batteries and for other purposes; as likewise for the preparation of the pigments chrome-yellow, orange and green, and also to some extent in the production of what is known as chrome-steel. 2. Of native antimony, which has been found at the Dufferin mine, on the 18th lot of the 1st concession of the township of Madoc, Hastings county, in the province of Ontario. 3. Of a series of specimens of what, as a result of this examination, has now been shown to be magnesite with variable, often comparatively small, quantities of intermixed dolomite, from more or less extensive exposures, and drift boulders, of the same, occurring in the township of Grenville, Argenteuil county, in the province of Quebec. The economic importance of this occurrence, may be inferred from the fact that magnesite is used in the preparation of magnesian salts—such as Epsom salts, magnesia, etc., also in the manufacture of paint, paper, and fire-brick, for which last named purpose it is especially well adapted, particularly where a highly refractive material is needed, as in the so-called basic process of iron-smelting. 4. Of an altered felsite from within half a mile of the stage stables at Hay cove, Red islands, Richmond county, in the province of Nova Scotia, where, from the information received, it is inferred that it occurs in considerable quantity. From experiments made with this material in the laboratory it is considered that it would make a fairly refractory fire-brick, in which regard it resembles the altered felsite from Watson

Numerous minerals of economic value.

brook, Cape Breton county, in the same province, the results of the examination of which, by the writer, are given in the Report of Progress of this Survey for 1875-76, p. 423. 5. An analysis of the somewhat rare mineral faujasite, a species not previously recognized as occurring in Canada, which was found, as described in my last report (Annual Report of this Survey, vol. 12, p. 17R, 1899), associated with the datolite met with in the workings of the Daisy mica mine, on the 9th lot of the 1st range of the township of Derry, Ottawa county, in the province of Quebec. 6. An analysis of a very beautiful amphibole from the township of Grenville, Argenteuil county, province of Quebec, which would appear to be adapted for an ornamental stone or for use in jewellery. 7. An analysis of a sample of underclay from a seam of lignite on Rock creek, about nine miles up from its entry into the Klondike, Yukon territory. This clay, the chemical composition and physical characters of which proved to be somewhat exceptional, was found to possess the property of decolorizing mineral oil, in which regard it resembles a fuller's earth. Examinations have also been made of many minerals from localities where they had not hitherto been met with, namely, of lampadite, or cupreous manganese, from the King Solomon mine, Copper camp, at the head of Copper creek, Yale district, in the province of British Columbia: of native copper, also from the King Solomon mine: of tremolite, from the Morrison mine, Deadwood camp, some three or four miles north-west of Greenwood city, Yale district, province of British Columbia: of rutile, from a quartz vein on Thistle creek, a tributary of the Yukon, Yukon territory: of bismuthinite, from the Blue Bell claim, Summit camp, near the head of Fisherman creek, Yale district, province of British Columbia: of melaconite, malachite, azurite, and cuprite, all from the King Solomon mine, Copper camp, at the head of Copper creek, Yale district, province of British Columbia; and of an asbestiform actinolite from a point on the Klondike about a mile and a half from its entry into the Yukon, Yukon territory.

Rare minerals.

Examinations of clays.

'8. Miscellaneous examinations, embracing: The examination of samples of clay in regard to their suitability for the manufacture of bricks, ordinary building bricks and fire-bricks, sewer-pipe, terra-cotta, stoneware, etc., from Marble mountain, Inverness county, province of Nova Scotia; Summer hill, parish of Gagetown Queens' county, and from the left bank of the Miramichi, about eighteen miles from its entrance into Miramichi bay, Northumberland county, in the province of New Brunswick; from the mouth of Savage river, a tributary of the Patapedia, Bonaventure county, from the four hundred and fifty-ninth lot

of the first range north-east, on the Chaudière, seigniory of St. Joseph, Beauce county, and from the fourteenth lot of the first range of the township of Wakefield, Ottawa county, in the province of Quebec; from the thirty-fourth lot of the sixth concession of the township of Lancaster, Glengarry county, and from the ninth lot of the eleventh concession of the township of Greenock, Bruce county, in the province of Ontario; from one mile west of the junction of the South fork and Little South fork of the Old Man river, district of Alberta, and from the Red Deer river, in the same district, as likewise from the vicinity of Moosomin, district of Assiniboia, in the North-west Territory; from Arrow lake, West Kootenay district, and from Texada island, Strait of Georgia, in the province of British Columbia.

The examination of a series of samples of the sand forming the Traverse Spit, at the foot of the Island of Orleans, and of that forming the Ste. Croix and Champlain shoals, between Three Rivers and Quebec, in the lower St. Lawrence, province of Quebec; of a siliceous sand from about two miles from the town of Shelbourne, Shelbourne county, province of Nova Scotia; of a sand from the bottom of a small lake on the eleventh lot of the tenth concession of the township of Greenock, Bruce county, in the province of Ontario; of an auriferous black sand from Adams hill, near Bonanza creek, and of a black sand from White Horse, Lewes river, Yukon territory. Of sands.

The examination of a marl from the fourteenth lot of the first range of the township of Wakefield, Ottawa county, and of that of another from the eleventh lot of the tenth range of the township of Bristol, Pontiac county, in the province of Quebec, as likewise of that of one from Loughborough lake, in Frontenac county, and of another from Odessa lake, Lennox county, in the province of Ontario. The examination of some silts from the township of Greenock, Bruce county, province of Ontario. Of marls.

The examination of an ore of manganese from Soldier cove, Bras d'Or lake, Richmond county, province of Nova Scotia; of a concretionary nodule from the vicinity of Sorel, south shore of the St. Lawrence, province of Quebec; of calcareous shales from Arnold, province of Manitoba; of a carbonaceous shale from Harris brook, Victoria county, province of Nova Scotia; of a bituminous shale from Chambord, township of Metabetchouan, Chicoutimi county, province of Quebec; of a sample of copper ore from Field, East Kootenay district, province of British Columbia; of a disseminated graphite from the ninth lot of the tenth concession of the township of Ross, Renfrew county, province of Ontario, and of another from Rivers inlet, in the province of British Columbia, as likewise of a prepared graphite from Of shales.

the works of the Dominion of Canada Plumbago Company, township of Buckingham, Ottawa county, province of Quebec; of an altered bitumen from the Falls on the Middle Fork of the Old Man river, district of Alberta, North-west Territory; of a sample of pyrite from the fourteenth lot of the fifth range of the township of Masham, Ottawa county, in the province of Quebec.

Various examinations. Examinations were also made of a great variety of other material from various parts of the Dominion, much of which, including those above referred to, called for, at least, a partial analysis.

'The total number of mineral specimens received for identification, analysis, or the obtaining of information in regard to their possible economic value during the past year, amounted to seven hundred and ninety-one (791). Many of these were brought by visitors, and the information sought in regard to them was in most cases communicated to them at the time of their calling. In other instances, however, such as those where a partial or complete analysis was considered desirable, as also in the case of specimens which had been sent from a distance, the results were communicated by letter. The number of letters personally written, in this connection,—chiefly of the nature of reports, and embodying the results of the examination, analysis, or assay, as the case might be, of mineral specimens—amounted to three hundred and twenty-one; and of those received, to one hundred and fifty-two.

Assistants in laboratory. 'Messrs. R. A. A. Johnston and F. G. Wait, assistants in the laboratory, have, as a result of the interest taken by them in their work, and their close and unremitting application to it, proved most efficient aids. Briefly stated, Mr. Johnston has carried out a large number of gold and silver assays, made many important mineral analyses, and, further, conducted a great variety of miscellaneous examinations; whilst Mr. Wait has made numerous analyses of natural waters, some mineral analyses, many partial analyses, and, in addition, also carried out very many miscellaneous examinations; all of which work will be given in detail in my ensuing annual report.

Assistant in mineral section. 'In the work connected with the mineralogical section of the museum, I have, as in previous years, had the hearty and able assistance of Mr. R. L. Broadbent. He has, in addition to the usual routine work of the museum—such as the labelling and cataloguing of all newly received specimens, and the maintenance of the collection generally in an orderly condition—also spent some time in the field for the purpose of collecting specimens for the museum, as well as others for

Mr. Willimott's use in making up collections for distribution to Canadian educational institutions. With this object in view, he visited several localities in the township of Hull, Ottawa county, of Grenville, Argenteuil county, and those of Litchfield and Calumet, Pontiac county, in the province of Quebec; and, further, the township of Ross, Renfrew county, and that of Lanark, Lanark county, in the province of Ontario. The minerals collected by him comprised :— Minerals collected.

	Specimens.	Weight.
Barite	....	200 pounds.
Fluorite (green)	13	
Porphyry	....	215 "
Scapolite	120	
Wollastonite	18	
Hornblende	....	100 "
Magnesite	...	150 "
Dolomite	200	
Zinc blende	....	300 "
Limestone (marble)	....	250 "
Galena	350	
Iron pyrites	....	300 "
Magnetite	....	350 "

'He has also devoted some time, to the preparation of a list of the additions to the mineralogical section of the museum during the last nine years. This, when completed, is intended to form an appendix to the "Catalogue of Section One of the Museum" (which embraces the systematic collection of minerals and the collection of economic minerals, etc.) published in 1893, thereby bringing it up to date.

The additions to the mineralogical and lithological section of the museum, during the past year, embraced :— Minerals added to museum.

(A.) Collected by members of the staff engaged in field-work in connection with the Survey :—

Ami, Dr. H. M.—

a. Mica (muscovite), garnet (almandite), felspar, graphic granite, garnetiferous gneiss, and hornblende, from Lac du Pied des Monts, Charlevoix county, Q.

b. Barite from lots 16 and 17, con. II of Kingston, Frontenac county, O.

Bell, Dr. R. :—

Zinc blende (sphalerite), from lots 5 and 6, con. III of Olden, Frontenac county, O.

Brock, R. W. :—

a. Cuprite, native copper, malachite, melaconite and lampadite, from the King Solomon mine, Copper Camp, Boundary creek district, B.C.

b. Bismuthinite, from Blue-bell claim, Summit camp, Boundary creek district, B.C.

c. Tremolite, from Morrison mine, Deadwood camp, Boundary creek district, B.C.

d. Calcite crystals from Knob Hill mine, Phœnix (Greenwood camp), Boundary creek district, B.C.

Dowling, D. B. :—

a. Magnetite from Sutton lake, west side of James bay, district of Keewatin.

b. Calcite from Equan river, district of Keewatin.

Leach, W. W. :—

Coal from the Coal creek, Michel and Morrissey mines, Crows Nest Coal Field, East Kootenay district, B.C.

McKinnon, A. T. :—

a. Gypsum from Clarks Head, Parrsboro', Cumberland county, N.S.

b. Amygdaloid from Two Islands, Cumberland county, N.S.

Wilson, A. W. G. :—

a. Hematite from south of Waboose lake, south-west of Lake Nipigon, district of Thunder bay, O.

b. Dolomite from north-east side of Narrows leading to Chiefs bay, Lake Nipigon, O.

(B.) Received as presentations—.

Allan, W. A., Ottawa :—

Fluorite crystals from lot 1, range IX of Derry, Ottawa county, Q.

Ami, Dr. H. M., (Survey) :—

Fragment of the 'Welland' meteorite, Welland, O.

Brumell, H. P. H., Buckingham, Q. :—

Contorted band of quartz in limestone, from lot 28, range VI of Calumet island, Pontiac county, Q.

Chute, J. A., Dawson, Yukon Territory, per J. B. Tyrrell :—
Native gold (crystal) from claim No. 16, Gold Run creek, Dominion creek, Yukon Territory.

Davis, M. P., Ottawa, O., per Dr. H. M. Ami, (Survey) :—
Granite from quarry at Rivière à Pierre, Portneuf county, Q.

Diver, D. :—
Marl from lots 3 and 4, con XI of Egremont, Grey county, O.

Haycock, E. B., Ottawa, per Dr. A. E. Barlow, (Survey) :—
Corundum from lot 14, con. IX of Methuen, Peterborough county, O.

Henderson, C., Madoc, O., per A. Blue, Ottawa :—
Talc from lot 14, con. XIV of Huntingdon, Hastings county, O.

Hungerford-Pollen, C., Fort Steele, B.C., per W. W. Leach, (Survey) :—
Hematite (crystallized) from the Stella mine, near Fort Steele, East Kootenay, B.C.

Low, A. P., Ottawa, O. :—
Dolomite from Hopewell sound, East coast of Hudson bay, Ungava district, N.E.T.

McPhee, Donald, Scotch Road, P. O., Argenteuil Co., Q. :—
Hornblende from lot 15, range IX of Grenville, Argenteuil county, Q. :—

Matheson, P., per Dr. H. M. Ami, (Survey) :—
a. Chalcopyrite, pyrrhotite and galena from Calumet island, Pontiac county, Q.
b. Pyrrhotite from near Renfrew, Renfrew county, O.
c. Quartz with iron pyrites, in chloritic schist, from lot 7, con. VIII of Ross, Renfrew county, O.

Messrs Moberly and Cameron, Collingwood, O. :—
Marl from lots 25 and 26, con. VII and VIII of Flos, Simcoe county, O.

Mitchell, W. D., New Denver, B.C. :—
Silver ores from mines and claims in the Slocan Mining area, West Kootenay, B.C.

a. Sphalerite with chalcopyrite and galena from the 'Fairy Queen,' southern slope of Ruby mountains.

b. Galena (so called ribbed ore) from the 'Convention Fraction,' Silver mountain, 3½ m. N. E. of New Denver.

c. An association of galena and iron pyrites, in quartz, from the 'Snifi' group, Silver mountain.

d. An association of galena and iron pyrites, in quartz, from the 'Mountain Chief,' Silver mountain.

e. Galena (so called ribbed ore) from the 'Bosun & Fidelity,' Silver mountain.

f. A vesicular quartz carrying a little galena, from the 'Empress,' twelve miles east of Silverton.

g. Quartz carrying small quantities of galena, tetrahedrite, and pyrite, from the 'Mollie Hughes,' foot of Goat mountain.

h. Quartz carrying small quantities of tetrahedrite, from the 'Capella' group, Goat mountain, one-quarter mile east of New Denver.

i. An association of quartz and calcite carrying a little tetrahedrite and pyrite, from the 'Ceylon,' Goat mountain, north of the Capella group.

j. A honeycombed quartz, stained and coated with ferric hydrate, from the 'Queen City' group, one mile east of New Denver.

k. A massive, fine to coarse, crystalline galena, from the 'Eclipse,' Silver mountain.

l. Quartz carrying small quantities of galena, from the north-west slope of the Ruby mountains.

m. Molybdenite from Wilson creek, Slocan lake, West Kootenay district, B.C.

Nadeau, J. A., Iberville, Q., per Dr. H. M. Ami, (Survey):—

Granite from the Mount Johnson quarries, Iberville county, Q.

Osman, C. J., M.P.P., Hillsborough, N.B., per Dr. R. W. Ells, (Survey):—

Gypsum showing wavy markings, from Hillsborough, Albert county, N.B.

Tyrrell, J. B., Dawson, Y. T.:—

Cassiterite (wood tin) from claim 39 above Discovery, Hunker creek, Yukon territory.

Wood, Hon. Josiah, Sackville, N.B.:—

a. Copper ore from the Intercolonial Copper Company's mine, Dorchester, Westmoreland county, N.B.

b. Copper ore (ground).

c. " (roasted).

d. Copper solution.

e. Electrolytic copper.

In addition to the foregoing, there have also been added to this section of the museum :— **Rock specimens acquired.**

258 specimens of rocks with microscopic sections, from the east side of Lake Winnipeg, collected by J. B. Tyrrell.

50 specimens of rocks with microscopic sections, from the Sudbury mining district, Ont., collected by Dr. R. Bell.

Mr. C. W. Willimott was engaged during the early part of the year in making up collections of minerals and rocks for various educational institutions. Later on, in the month of July, he visited the township of Wakefield, Ottawa county, P.Q., on which occasion he collected the following material :— **Educational collections.**

Garnet (almandite)	200 specimens.
Scapolite	200 "
Diorite	200 "
Phlogopite	300 crystals.
Apatite crystals in calcite	150 specimens.
Pyroxene crystals	750 "
Serpentine	100 lbs.
Calcite	100 "

He received from

Mr. Allan McKinnon :—

Agate, about	300 lbs.
Fibrous gypsum, about	200 "

Mr. D. Farry, Ottawa :—

Shell marl	25 lbs.

Mr. Robertson, Albert mines, N.B.:—

Albertite	1 barrel.

Mr. Parks, Eganville, Ont.:—

Aventurine (feldspar)	40 lbs.

Collections sent.

The following is a list of the educational institutions to which named collections of minerals have been sent during the year :—

	Specimens.
St. Denis Academy, Montreal	75
Public school, W. Pubnico, Yarmouth county, N.S	75
Jacques Cartier Normal School, Montreal, Que	100
Les Sœurs de la Congregation de Notre Dame, Sherbrooke, Que	75
Public school, Warkworth, Northumberland co., N.B	100
Sacred Heart Academy, Montreal, Que	75
St. Urbain Academy, Montreal, Que	75
Public school, Dundela, Ont	100
Cookshire Academy, Cookshire, Que	100
Sisters of Charity, St. Bernards School, Moncton, N.B	100
Public school, Boistown, N.B	100
" Brighton, Digby co., N.S	75
Convent of Sacred Heart, Sault Ste. Recollet, Que	75
Freeport school, Freeport, Digby co., N.S	125
Public school, Eganville, Ont	100
" Comox, B.C	75
Dalhousie College, Halifax, N.S	125
Public school, Ulverton, Que	100
Academy of St. Joseph, Montreal, Que	100
St. Paul's College, Varennes, Que	100
Collegiate Institute, Ridgetown, Ont	125
School, District No. 2, Pt. Wolfe, Albert co., N.B	100
Alexandra school, St. John, N.B	100
Louisburg school, Louisburg, C.B., N.S	100
Agnes and Megantic Model School, Lake Megantic, Que.	100
Public school, Armstrong, B.C	100
High school, Vernon, B.C	125
Public school, Sandwich, B.C	100
School, Chester, Lunenburg co., N.S	125
High school, Mabou, C.B., N.S	75
Village school, Melbourne, Que	75
High school, Toronto Junction, Ont	125
Cambridge St. school, Ottawa, Ont	100
Grammar school, Sussex, N.B	100
Public school, Grand Forks, B.C	100
College St. school, Halifax, N.S	100
High school, Somerset, Kings co., N.B	125
Industrial Advocate, Halifax, N.S	75
Derby Superior school, Millerton, N.B	100
Public school, Richmond, Ont	100
Museum, Gerrard Road, Rotherham, Eng	125
College St. Louis, St. François de Beauce, Que	100
St. Alban's school, Brockville, Ont	100
Congregation de Notre Dame, Port Hood, C.B., N.S	75
Loyola College, Montreal, Que	125
Collegiate Institute, Chatham, Ont	125
School, Parkers Ridge, N.B	75
Sacred Heart, Arthabaskaville, Que	100
Bellevue Convent, Notre Dame de Bellevue, Que	75
London School Board, London, Eng	75
Public school 170, New York, U.S	75
Convent Jesu Marie, St. François de Beauce, Que	75
Normal school, Vancouver, B.C	125
Public Library, Bruce Mines, Ont	125
High school, Bridgetown, N.S	125
Collegiate Institute, Brockville, Ont	125
" Jarvis St., Toronto, Ont	125
Government Agricultural school, Compton, Que	125
Coaticook Academy, Coaticook, Que	125
Public school, Dresden, Ont	75
High school, Athens, Ont	125
Public school, Bideford, P.E.I	75
Guillet's school, Ottawa, Ont	75
	6,250

The undermentioned have also been supplied with certain specimens of Canadian minerals, viz.:—

R. M. Thorburn, St. John's, Newfoundland............	4
H. Parkhurst, Rockport, Ont...........................	4
T. J. McFarlane, New Glasgow, N.S. (in exchange).....	34
W. E. Cunningham Lamott, Pennsylvania, U.S	1
H. Piers, Provincial Museum, Halifax, N.S.............	2
Ed. Locke, Shrub Hill, Worcester, England............	3

Report of the Mines Section for 1902.

Mr. E. D. Ingall.

Of the work of the Mines Section, Mr. E. D. Ingall reports as follows:—

The functions of the Section in relation to the mineral resources and industries of Canada have been performed during the past year as far as the means at disposal permitted. The staff of the Section numbers three, namely: the officer in charge, upon whom, in addition to the general direction of the Section, most of the technological work devolves; Mr. J. McLeish, who, besides what help he renders in the general work, has special charge of the statistics, and Mrs. W. Sparks whose duties are numerous and general. During part of the winter months Mr. T. Denis, formerly attached to the staff but now entrusted with field geological work, has helped in the technological work. For four months during the summer and part of the winter, Mr. Ingall was engaged in field geological work in the district of Algoma. Staff.

As comparison has been frequently and publicly made of the results attained by us with those of the equivalent branch of the Geological Survey of the United States, it may be well to draw attention to certain facts bearing upon this point, without which such a comparison is misleading. Comparison with United States.

The objects of both branches are practically the same, viz: to study and report upon the economic mineral resources of the country, and upon the mineral industries resulting from their exploitation. The results attained take shape chiefly in the form of the annual reports, which should contain, not merely the statistics illustrative of the mineral production but technical descriptions of the mining and allied industries; concise descriptions of the mineral deposits, etc.

The statistics have been issued regularly by this Section since 1886, taking the form of a preliminary advance statement, issued soon after the close of the year dealt with, followed later by the full annual

report giving revised and more complete figures accompanied by much explanatory matter. From time to time special technological articles have been included covering various industries, and a commencement is now being made to carry out the plan suggested some years ago, of issuing these in pamphlet form under the name of bulletins.

With the extensive field of work offered by the Dominion with its scattered and mostly unorganized mineral industries, it has been found impossible to do more than make a beginning along these lines, and with the present rapid growth of our mineral industries a much more vigorous policy is needed to meet even the most pressing needs of those interested directly or indirectly in exploiting our mineral resources. As giving some idea of the cost of such work it may be mentioned that the Division of Mining and Mineral Resources of the United States Geological Survey has at its disposal an annual grant of $50,000, whereas we receive only about one-tenth of that amount. The staff engaged on their work numbers some thirteen besides outsiders who write up special industries, where we number from two to four only. It is true their mineral industries produce fifteen times as much as those of Canada, but owing to the mineral deposits of our own country being scattered over so extensive a territory, and to the industries being as a rule unorganized and often ephemeral, the work of keeping in touch with discovery and development is proportionately very much greater.

Cost of each.

In view therefore of these facts and of the present needs of the public interested in our mineral resources and industries, it would seem that the time is quite ripe for the reinforcement of the Mines Section, so that it may more vigorously and completely carry out the policy inaugurated in the past, but largely held in abeyance so far by want of means.

Advance statements.

An attempt has been made in the following pages to give a resumé of the mineral industry of Canada. The advance statement herewith reproduced, was issued on the fourth of the month, and to it is added any information as to the different industries which was not available thus early in the year (13th March). It is hoped that an extension of the system may be possible in the future, rendering available more complete and reliable data even thus early. At present however much of the matter given in this preliminary statement must be taken as subject to revision later in the year.

SUMMARY OF THE MINERAL PRODUCTION OF CANADA IN 1902.

(Subject to Revision.)

Product.		Quantity. (a)	Value. (a)
Metallic.			$
Copper (b)	Lbs.	39,168,202	4,553,695
Gold, Yukon	$ 14,500,000		
" all other	6,241,245		
		....	20,741,245
Iron ore (exports)	Tons.	428,901	1,065,019
*Pig iron from Canadian ore	"	71,665	1,043,011
Lead (c)	Lbs.	23,000,000	935,870
Nickel (d)	"	10,693,410	5,025,903
Silver (e)	Oz.	4,373,000	2,280,957
Zinc	Lbs.	166,700	8,068
Total metallic		....	35,653,768
Non-Metallic.			
Actinolite	Tons.	550	4,400
Arsenic	"	800	48,000
Asbestus	"	31,779	1,191,338
Asbestic	"	8,662	12,114
Chromite	"	900	12,400
Coal	"	7,639,255	15,538,611
Coke (f)	"	506,466	1,538,930
Corundum	"	768	84,468
Felspar	"	7,576	11,375
Fire clay	"	2,741	4,283
Graphite	"	1,095	28,300
Grindstones	"	6,159	48,400
Gypsum	"	332,045	356,317
Limestone for flux	"	293,108	218,809
Manganese ore	"	84	2,774
Mica	"	....	400,000
Mineral pigments—			
Baryta	"	1,096	3,957
Ochres	"	4,955	30,495
Mineral water		....	100,000
Moulding sand	Tons.	13,352	27,651
Natural gas (g)		....	195,992
Peat	Tons.	475	1,663
Petroleum (h)	Brls.	521,485	934,740
Phosphate	Tons.	856	4,953
Pyrites	"	35,616	138,939
Salt	"	63,056	288,581
Talc	"	689	1,804
Tripolite	"	900	15,800

*The total production of pig iron in Canada in 1902, from Canadian and foreign ores amounted to 357,903 tons, valued at $4,243,545, of which it is estimated 71,665 tons, valued at $1,043,011, should be attributed to Canadian ore and 286,238 tons, valued at $3,200,534, to the ore imported.

(a.) Quantity or value of product marketed. The ton used is that of 2,000 lbs.
(b.) Copper contents of ore, matte, &c., at 11·626 cents per lb.
(c.) Lead contents of ores, &c., at 4·069 cents per lb.
(d.) Nickel contents of ore, matte, &c., at 47 cents per lb.
(e.) Silver contents of ore at 52·16 cents per oz.
(f.) Oven coke, all the production of Nova Scotia and British Columbia.
(g.) Gross return from sale of gas.
(h.) Includes crude oil sold to refiners and oil sold for fuel and other purposes.

SUMMARY of Mineral Production of Canada in 1902—*Concluded.*

PRODUCT.	Quantity. (a)	Value. (a)
STRUCTURAL MATERIALS AND CLAY PRODUCTS.		$
Cement, natural rock .... Brls.	124,400	91,870
" Portland .... "	594,594	1,028,618
Granite	....	170,000
Pottery	....	200,000
Sands and gravels (exports) .... Tons.	159,793	119,120
Sewer pipe	....	294,465
Slate	....	19,200
Terra-cotta, pressed brick, &c	....	348,597
Building material, including bricks, building stone lime, tiles, etc	....	5,500,000
Total structural materials and clay products	....	7,771,870
" all other non-metallic	....	21,245,094
Total non-metallic	....	29,016,964
" metallic	....	35,653,768
Estimated value of mineral products not returned	....	300,000
Total, 1902	....	64,970,732
1901, Total	....	66,712,708
1900 "	....	64,505,137
1899 "	....	49,584,027
1898 "	....	38,697,021
1897 "	....	28,661,430
1896 "	....	22,584,513
1895 "	....	20,648,964
1894 "	....	19,931,158
1893 "	....	20 035,082
1892 "	....	16,628,417
1891 "	....	18,976,616
1890 "	....	16,763,353
1889 "	....	14,013,913
1888 "	....	12,518,894
1887 "	....	11,321,331
1886 "	....	10,221,255

REMARKS.

Slight decrease.

Notwithstanding the most gratifying increase in the total value of the production of non-metallic minerals, the grand total of the value of the production of all the mineral industries of Canada, shows a falling off of 2·61 per cent. This is due not merely to the decrease in the Yukon output of gold of $3,500,000, but also to the very considerable falling off in values of all the remaining metallic minerals except nickel. But for the large growth of the coal and coke industry, helped by increases in many of the other non-metallic products, the decrease in the grand total, on account of the falling off in the metallic class would have amounted to nearly 10 per cent. The total of the metallic

products, shows diminution amounting to over ontput 15 per cent, as compared with the equivalent figures for 1901, whilst the non-metallic class shows an increase of over 20 per cent in a similar comparison.

In regard to their relative importance, the metallic industries as a group, still occupy the most important place, although not leading to the extent they did in former years. They contributed about 55 per cent of the whole, the non-metallic following with nearly 33 per cent, and the structural class with nearly 12 per cent. Grouping the metalliferous class with coal and coke, about 81 per cent of the value is accounted for. Proportion of metallics.

The following table gives the relative contribution to the grand total of the different mineral industries in comparison with 1901.

1901.		1902.	
Product.	Per cent of total Production.	Product.	Per cent of total Production.
1 Gold	36·17	1 Gold	31·92
2 Coal and coke	17·99	2 Coal	23·92
3 Copper	9·14	3 Building material	8·47
4 Building material	7·71	4 Nickel	7·74
5 Nickel	6·89	5 Copper	7·01
6 Silver	4·89	6 Silver	3·51
7 Lead	3·37	7 Coke	2·37
8 Asbestus	1·89	8 Asbestus	1·85
9 Coke	1·84	9 Cement	1·72
10 Pig iron (from Canad'n ore)	1·82	10 Iron ore (exports)	1·64
11 Petroleum	1·51	11 Pig iron (from Canad'n ore)	1·61
12 Iron ore (exported)	1·14	12 Lead	1·44
13 Cement	0·99	13 Petroleum	1·44
14 Gypsum	0·51	14 Mica	0·62
15 Natural gas	0·51	15 Gypsum	0·55

It will be noted that copper has fallen from third to fifth place; lead from seventh to twelfth. Iron ore exported has advanced two places, but pig iron from Canadian ore is now eleventh in importance, where last year it ranked tenth. Silver maintains its position, whilst nickel advanced to fourth.

Increases and decreases.

INCREASE AND DECREASE IN 1802.

Product.	Quantity.		Value.	
	Increase.	Decrease.	Increase.	Decrease.
	p c.	p.c.	p.c.	p.c.
Metallic—				
Copper	3·54			21·99
Gold				14·04
Pig iron (from Canadian ore only)		13·76		13·95
Pig iron (from both home and imported ores)	30·44		20·80	
Lead		55·68		58·39
Nickel	16·37		9·39	
Silver		21·05		30·15
Arsenic	15·27		15·17	
Non-metallic—				
Asbestus and asbestic	0·55			3·67
Coal	22·67		29·43	
Coke	38·56		25·30	
Corundum	82·88		59·03	
Cement	59·64		69·76	
Gypsum	13·02		4·75	
Petroleum		16·21		7·29
Salt	6·10		10·01	

In studying the above table, it will be noted that the showing made by the metallic class as a whole is in great contrast with that exhibited by the non-metallic class. In the former case, although copper, pig iron as a whole, and nickel, were turned out in larger quantities than last year the beneficial results were modified or even reversed by the lower values obtained. In all the other metallics, the heavy falling off in production is markedly aggravated by the fall in values in these instances also.

Non-metallics.

In the non-metallic class, there is fortunately a better record. Only in the cases of asbestus, asbestic and petroleum do the values show decreases, whilst for all the other items the proportional growth is very marked. Although in several of the industries there has been a falling off in values, in others on the contrary, the increase has been very marked.

Iron smelting.

It will be noticed that although the output of pig iron from Canadian ore has fallen off, the whole iron smelting industry shows notwithstanding marked growth. Taking the values of the coal and coke produced during 1902, together with those in the allied iron smelting industry, an increase of nearly $4,500,000 is exhibited, shewing a

growth in these, the most commercially important industries of the country, more than offsetting the falling off of the $3,500,000 in the necessarily fluctuating product of the placer gold washings of the Yukon territory.

The value per capita of the total mineral products compared with our population was $11.87 in 1902, as against $2.23 in 1886, the first year for which figures are available.

Viewing the different industries separately some of the more interesting features are given below :—

Important features of different industries.

Copper.—Despite the drop in copper values during the latter months of 1901 and the continuation of low prices throughout 1902, an average of less than 12 cents per pound at New York, there was produced in Canada in 1902 nearly 20,000 tons of copper in ore, matte, etc., which was a slight increase over the output of the previous year. In the eastern part of Canada, perhaps, one of the most interesting features of this industry was the production of electrolytic copper by the Intercolonial Copper Company at their works in New Brunswick. The pyrites ores at Capelton, Quebec, are at present the chief source of copper production in this province, and the output varies but little from year to year. In Ontario the nickel-copper ores of the Sudbury district were worked to about the same extent as during the previous year. Extensive preparations, however, are being made, it is said, to push operations vigourously during 1903 and a largely increased output is confidently looked forward to for 1903. In British Columbia there was an increased production of copper. From the Rossland district about 350,000 tons of gold-copper ore were shipped to the smelters, while over 500,000 tons of the low-grade copper ores of the Boundary district were mined and shipped.

Gold.

Gold.—The gold mining industry in Canada in 1902 shows no radically new features. The output of the Yukon placers continues to decrease, the output for 1902 being estimated at $14,500,000 in the preliminary statement. This estimate is based on receipts at United States mints. Royalty was paid on gold officially valued at $12,018,-561. As, however, for the purposes of the royalty, the gold is arbitrarily valued at $15 per ounce, and as much of the gold is really worth more than this, the actual value of the gold sent out of the country would necessarily be somewhat more than that represented by the royalty certificates. Then, again, some allowance will have to be made for gold in small amounts on which no royalty is payable, and on that smuggled out to avoid payment of royalty. Taking these

various items into consideration it will probably be found that the above estimate of $14,500,000 is not excessive. The output of the other established gold mining districts continues with practically the same results as during the previous year.

Iron.

Iron.—The production of iron ore in Canada is not at present commensurate with the iron smelting interests of the country. The total quantity of Canadian ore used in Canadian furnaces was 125,664 tons, in addition to 539,381 tons of imported ore. The total quantity of pig iron made was 459,902 tons (of 2,000 lbs.) Of this product 237,244 tons were made in Nova Scotia in the furnaces of the Dominion Iron and Steel Company and the Nova Scotia Steel and Coal Company. Quebec furnaces contributed 7,970 tons, and Ontario furnaces at Deseronto, Hamilton and Midland produced 112,688 tons. The product of the Quebec furnaces at Radnor Forges and Drummondville and of the Deseronto furnace in Ontario, is charcoal pig iron, while coke is used as fuel in all the other furnaces.

The Clergue interests at Sault St. Marie have been erecting blast furnaces at that place, intended to use charcoal as fuel, but these have not yet been completed.

The manufacture of steel is rapidly becoming an important feature of Canada's metallurgical industries. Over 150,000 tons were made in 1902, valued at nearly $3,000,000. A steel rail plant was completed and placed in operation at Sault Ste Marie. Continuous operation, however, has not been maintained so far.

Lead.

Lead.—The quantity given in the above tables practically represents the contents of the ores produced from all the British Columbia mines. The output of 1902 has fallen off over 55 per cent as compared with the previous year. The silver output of this province has also suffered in sympathy with the lead, although not nearly to the same extent as explained under the heading silver.

Nickel.

Nickel.—The nickel industry exhibits, in 1902, but little change so far as quantity of production is concerned. This has already been referred to in connection with copper. In addition, it may be said that the ore smelted amounted to 211,847 tons, producing 23,211 tons of ordinary matte carrying an average of about 19·4% of nickel and 2,100 tons of Bessemer matte averaging 40·27% nickel. Besides the product sold by the Canadian Copper Co. and the Mond Nickel Co. a considerable tonnage of ore was mined by the Lake Superior Power Co. at the Gertrude and Elsie mines. The greater part of this was

sent to the roast heaps, a small portion going to the reduction works at Sault Ste. Marie.

Silver.—Although British Columbia is the chief silver-producing province of the Dominion, small quantities have, as usual, been produced from some of the other well-known districts, viz., that obtained as a by-product from the pyrites ores near Capelton, Quebec, that from the mines in Thunder Bay district, Ontario, and the silver found in association with the placer gold of the Yukon Territory. In British Columbia there was a falling off in the production. The general conditions affecting this industry have already been referred to in part in treating of the lead product. The ores of the Rossland and Boundary districts, however, carry appreciable quantities of silver and an increase in the production of these ores has to some extent offset a decrease in the output of the silver and silver-lead ores. Silver.

Zinc.—The production of zinc as given in the preliminary summary table of mineral production was all derived from a newly opened mine in the township of Olden, Frontenac county, Ontario. Although no statistics of zinc ores in the province of British Columbia are as yet available, there appears to have been some demand during the year from the United States for zinc ores from this province, and several shipments are reported as having been sent to Kansas. Zinc.

Coal.—Amongst the non-metallic minerals coal is by far the most important. It contributed in 1902 nearly 24 per cent of the total mineral production in Canada, being exceeded only by gold, and shows an increase of more than 22 per cent over the output of 1901. Coal-mining operations were especially active in Nova Scotia, where the coal sold during the year amounted to 4,229,120 long tons. Of this amount over 33 per cent was sold within the province, over 40 per cent found a market in New Brunswick, Prince Edward island, Quebec, etc., while the balance was exported, chiefly to the United States. Coal.

The average value placed upon the coal product of this province at shipping points on the authority of Mr. C. Shields, vice-president of the Dominion Coal Company, was $2 per long ton. There has been a considerable demand in adjacent portions of the United States for Nova Scotia coal, intensified no doubt by the stringency in the supplies of anthracite coal due to the long strike of the anthracite miners in Pennsylvania. The action of the United States government in removing the duty for the period of one year on bituminous coal entering that country will probably result in largely increased shipment Demand for Nova Scotia coal.

of Nova Scotia coal in that direction. A substantial increase was made in the output of coal from the North-west Territories from the well established mines at Souris and Roche Percé, Lethbridge, Anthracite, Canmore, Frank and from the many small mines in the Edmonton district.

The Crow's Nest Pass Coal Co. continued to develope their properties They did not however, owing to an unfortunate explosion in May, 1902, and several subsequent strikes, materially increase their output.

The production of the Vancouver Island collieries was somewhat less than during the previous year.

A largely increased quantity of coke was made during 1902 to meet the requirements of smelting operations.

Other Non-metallic Minerals.—Amongst other non-metallic minerals important increases are shown in *arsenic*, *corundum*, *cement* and *gypsum*. Arsenic was produced to the extent of 800 tons, valued at $48,000. This output is of interest as being the only production of arsenic on this continent. The asbestus mining industry of the eastern townships, Quebec, exhibits but little change from the previous year, the output of 1902 being valued at $1,203,452.

Corundum production shows an increase of over 80 per cent compared with 1901. This industry, although only commenced in 1900, is showing a strong and steady growth. The output is derived from the Craig mine in the township of Raglan, Renfrew county. The Ontario Corundum Company has also begun operations in the township of Carling, Hastings county.

Other mineral products. Much might be written with regard to numerous other mineral products, but these hardly call for special mention at the present time, with the exception perhaps of Portland cement. A good deal of energy has been displayed during the past two years in the establishment of mills for the manufacture of Portland cement from marls and clay, &c., chiefly in the province of Ontario. There were eight Portland cement works in operation during 1902 as compared with four in 1901. The capacity of the works in operation in 1902 was about 3,000 barrels per day, while one mill with a capacity of 1,000 barrels per day was almost ready for operation at the close of the year, making the total capacity of Portland cement works already in operation at the beginning of 1903 about 4,000 barrels per day. The total quantity of Portland cement made in 1902, was 526,335 barrels, while the sales were 558,594 barrels. Stock in manufacturers' hands on the 1st January, 1902, were 65,705 barrels, and at the close of the year 33,446 barrels.

Imports of cement during six months ending December, 1902, were 1,255,495 cwt., or about 313,874 barrels, valued at $482,915. Cement.

In the general statement of the mineral production for the year, as contained in the summary of the mineral production of Canada in 1902 (subject to revision), the metallic production is given in terms of fine metal contained in ore, matte, etc., and valued at the final market value of the metals in some standard and recognized market. This has been considered as the most satisfactory method for the purpose of a general statement and for use in comparison with past years and with other countries. Such compilation, however, does not make any less useful or interesting a statement of the production of raw ores during the year, although to give a fair monetary value to the raw materials as shipped from the various mines, would be a matter of no small difficulty.

Manifestly the materials representing the first product as shipped from the works or mines will represent various and changeable values. For instance, of the different districts contributing to the output of copper, some produce raw ore and some partially finished products of processes of extraction. Confusion also arises from the fact that the values of given ores, etc., depend upon the presence of other constituents.

Then the spot values, depending as they do upon the extent to which extraction processes have been carried, are not only not comparable from year to year, owing to changes in practice, but the differences in condition and value between these varying sources of the same metal are such as almost to necessitate their separation into different classes.

In British Columbia, according to the annual report of the provincial mineralogist the tonnage of metalliferous ores mined was as follows by districts : Tonnage of metalliferous ores mined in B. C.

	Tons.
Grand Forks, Kettle River and Osoyoos Division	521,402
Rossland	329,534
Nelson	77,810
Slocan and Ainsworth	26,092
Coast	31,802
East Kootenay	3,881
Other districts	8,478
	998,999

Ontario produced iron ore, nickel, copper ores, gold quartz, etc., to the extent of about 725,000 tons.

In Quebec the pyrites ores of Sherbrooke, though worked primarily for sulphuric acid, may, owing to their copper and silver contents, be classed as metalliferous. These, with iron ores and galena, and including the copper ores of New Brunswick, might account perhaps for about 60,000 tons in 1902.

METALLURGY.

Work by Mr. Donald Locke.

In October it was decided to employ Mr. Donald Locke, a graduate of Freiburg School of Mines, as metallurgist and assayer. On October 21 Mr. Locke left Ottawa for Sudbury with instructions to make a short report on the copper-nickel smelting processes of the Canadian Copper Company, the Ontario Smelting Works at Copper Cliff, and the Mond Nickel Company at Victoria Mines.

He was engaged in making the necessary examination of the various processes till November 4 when he returned to Ottawa. His summary report is as follows :—

Canadian Copper Company's works.

At the Canadian Copper Company's works there were, at the time of my visit, eight Herreshof blast furnaces in operation, each smelting about 130 tons a day. The ore, which is heap-roasted, is practically self fluxing, only a small quantity of quartz being added. It contains about 1½ per cent copper and 2½ per cent nickel. Each furnace produced nearly 13 tons of matte containing about 12 per cent copper and 22 per cent nickel. The matter is tapped at intervals from the forehearth and when cold is broken and sent to the Ontario Smelting Works for concentration. The slag flowing continuously from the foreheath is granulated in McArthur granulating troughs. It assays about 0·27 per cent copper, 0·40 per cent nickel, 32 per cent silica and 40 per cent iron.

An experimental plant is in course of erection to see what can be done in the way of smelting pyritically. It is hoped to reduce the coke consumption to 3 or 4 per cent of the charge by using a hot blast and an oxydizing atmosphere in the furnace and utilizing the heat developed by the burning of the sulphur and iron of the ore.

The Ontario Smelting Works were concentrating the matte from the Canadian Copper Company to a matte containing 25 to 30 per cent copper and 50 to 55 per cent nickel.

Concentration of matte.

The matte arriving from the Canadian Copper Company is reduced to a fine powder and roasted in Brown straight-line calciners, reducing the sulphur from 25 to 30 per cent down to 5 to 8 per cent. The

roasted matte is smelted in two Oxford furnaces, being put through in thhe powder with quartz tailings and some roasted ore. Matte and slag are separated in the Oxford siphon-tap forehearth whence they flow in continuous separate streams into cast iron slag pots; the matte is sent to the Oxford Company, N.J., for the separation of copper and nickel, and the slag returns to the Canadian Copper Company's works where it is resmelted to extract the nickel and copper it contains.

The Mond Nickel Company at Victoria mine treats the ore from its own mine, producing a concentrated matte with about 80 per cent copper and nickel and ½ per cent iron; this is sent to Clydach, Wales, to be treated there by the Mond process for copper and nickel. Mond Nickel Company.

The heap-roasted ore is brought to the smelter by an aerial tramway and tipped into bins above and behind the blast furnace feed floor.

The ore, assaying about 2·5 to 3 per cent copper and about 3 per cent nickel, is smelted in rectangular, steel waterjacked furnaces 12 feet high and 44 inches by 120 inches at the tuyeres; the two furnaces (only one runs at a time) have each 16 tuyeres, 8 on each side, a water-cooled cast iron tap jacket and Hixon slag spout. One furnace puts through about 170 tons a day. The charges are dumped directly from the dump cars into the furnace through the open top, alternate charges being fed to the sides by means of a simple device consisting of a wrought iron pipe about 8 inch diameter, the length of the furnace opening, and let down about three feet into the furnace; on this the charge falls and is deflected towards the sides.

The blast is pre-heated by leading the air from the blowers through a channel built above the dust flue and separated from it by a steel diaphram, thus utilizing the waste heat of the furnace gases.

The forehearth is of boller iron, 9 feet in diameter and 3 feet 6 inches high, with a 6-inch lining of fireclay and quartz; from the foreheath the slag flows continuously and is granulated by a powerful stream of water.

The matte is tapped periodically and flows into the converters, which ar esituated on the lowest level of the smelter. About 20 tons of matte are produced per day by one furnace, assaying about 13 per cent copper and 15 per cent nickel.

In the converter department are six horizontal converters of the modified leghorn type, only one of which is in use at a time, the others Converter

being repaired, lined or dried; the converters are 6 feet 8 inches in diameter and 7 feet long; they rest on roller wheels supported by a strong cast-iron frame and are revolved by a vertical rack bar extended downward into a hydraulic cylinder and geared with a toothed wheel attached to the converter. The first charge of a newly lined converter is only about one ton, but as the lining is eaten the size of the charge increases, the average charge being about two tons—a lining lasts 11 to 12 hours, about six charges being blown in this time; a blast of 10 lbs. pressure is employed; the concentrated matte contains about 80 per cent nickel and copper—when cold it is crushed and packed in barrels to be sent to Wales for further treatment. The converter slag is put through the blast furnace to recover its metal contents.

MAPPING AND ENGRAVING.

Mr. C.-O. Senécal, Geographer and Chief Draughtsman.

Report of geographer and chief draughtsman.

Mr. Senécal reports as follows on the work accomplished under his supervision during the calendar year 1902:—

Staff.

As usual the field assistants who attend to mapping during the winter months left early for the field, and from June to October, the office work was carried on by only a few draughtsmen. Although the progress was satisfactory, this staff is still insufficient to keep pace with the increasing demands made on this office. One or two good map draughtsmen are required to compensate for the assistants who are regularly detached for field-work and who necessarily have to devote considerable time to the preparation of their returns. The intermittent delays in the compilation of some of the maps could, in a measure, be thus avoided.

Routine work.

The general work of laying down geographical projections for new maps, correcting report and map proofs, preparing memoranda on various subjects for the information of the director, the librarian and correspondents, auditing map accounts, collecting and listing instruments for repairs, making office and field tracings, blue-prints, distributing printed maps, etc., was attended to. In this connection it is also desirable to obtain the services of a general office assistant, whose duty would be to attend to the cataloguing of survey records, manuscript sheets and other documents, do typewriting and general draughting. At present, this work which also includes the care and distribution of field instruments, devolves upon the draughtsmen and it is the cause of much delay in the regular map work, while I am

constantly under obligation to the typewriters of the other sections of the department, for copies of map specifications, letters, etc.

The work has been distributed as follows:—

Mr. L. N. Richard has completed the compilation of the Bancroft map and has drawn the same for engraving. He has prepared the colour copy of the Manitou sheet—sheet No. 4, Western Ontario—has compiled and drawn for engraving the map of Shefford mountain; has traced the greater part of Perth sheet—sheet No. 119, Ontario—for engraving; has made several zinc-cut drawings for various reports and has spent some time in tracing plans of new surveys, correcting map-proofs, etc. Mr. Richard has now in hand a general index-map of the Dominion, showing the progress of the Geological Survey to the present time. **Assignment of work.**

Mr. W. J. Wilson has, for the greater part of the time spent in the office, been engaged on the compilation of the Ontario sheets Nos. 143 and 156 covering the Michipicoten mining district. His surveys, as well as those of Dr. R. Bell made in that region have all been reduced to the scale of publication, but before final adjustment can be made on the sheets, certain plans of surveys of the Ontario government and of the Algoma Commercial Co., are required. As soon as these plans will have been received the sheets will be promptly finished.

Mr. Wilson, accompanied by Mr. O'Sullivan, left for the field at the end of May, to explore new country in Keewatin district. Since his return, he has been engaged in compiling a map of this exploration for the present Summary Report. Mr. Wilson also spent some time plotting, etc., and writing his report.

Mr. J. F. E. Johnston has completed the compilation of the topographical map of the Klondike mining region and has prepared lists and memoranda of repairs of instruments. He has completed and filed the plotted sheets and note-books of his surveys of 1899 to 1901 and left for the field with Dr. Alfred W. G. Wilson of Montreal, for an exploration of the country north of Lac Seul, Keewatin. Since his return, Mr. Johnston has plotted part of his work, and began the compilation of a map for this year's Summary Report. He is at present on sick leave.

Mr. O. E. Prud'homme has drawn and lettered for engraving, the plans of Lake Catcha, South Uniacke, and Tangier gold districts, Nova Scotia; the sheets Nos. 59, 60, 61 and 62 of the Nova Scotia series and the map of Klondike mining region. He has pre-

pared the lithographer's copy, (crayon shading) for the topographical edition of the West Kootemay sheet, B.C.; has drawn several zinc-cut illustrations for geological reports, and has drawn for photolithographing the Orographic map of Turtle mountain, Manitoba, and a section of Blue-nose gold mine, Nova Scotia.

Distribution of printed maps.

Mr. Prud'homme has, as usual, attended to the distribution of the printed maps held for sale and distribution. I may here remark that the time spent on this work—which does not properly belong to my office, and is the cause of much delay in Mr. Prud'homme's regular work,—is very considerable, and I would suggest that the stock of printed maps be placed under the direct control of the librarian, and the draughtsman relieved of the distribution.

Mr. J. Keele has completed the compilation of sheets Nos. 119 and 122, Ontario and Quebec series, and spent some time in plotting surveys made by Dr. A. E. Barlow, in Sudbury district, Ontario. He left for the field on June 4, as topographer for Mr. R. G. McConnell, and surveyed the Pelly and MacMillan rivers and tributaries for about 500 miles, He returned to the office on October 17, and has since compiled and drawn a map of the above explorations for the Summary Report.

Mr. W. H. Boyd has assisted Mr. D. B. Dowling in compiling the final map of Ekwan and Trout rivers, Keewatin district; has prepared an office index-map of the various explored fields of the Yukon Territory, and spent most of his time in plotting and putting in shape Mr. R. W. Brock's surveys of 1901. He accompanied this officer in the field last summer as topographer from June 29 to October 10, and surveyed part of the Boundary mining district, British Columbia. He is at present reducing and compiling his data for publication.

Mr. J. A. Robert has continued the compilation of Mr. H. Fletcher's surveys on sheets Nos. 64, 65, 73, 76, 77, 78 and 81 of parts of the counties of Cumberland, Colchester and Hants, Nova Scotia. He has prepared the colour copy for sheets Nos. 44 to 48 and 56 to 58, Nova Scotia; has traced part of sheets Nos. 59 and 60, Nova Scotia, for engraving; has corrected map-proofs and made a large number of tracings of plans of new surveys for the Nova Scotia sheets

He compiled, from recent data, additions to Mr. H. M. Poole's map of Pictou coal-fields which will shortly be in shape for publication.

Mr. Robert has also prepared a set of drawings for colour patterns for geological sheets and the model of a protractor plotting sheet for copper plate engraving.

He is at present tracing a map of Springhill coal-fields for the Summary Report.

Mr. O. O'Sullivan has almost completed the compilation of the topography on sheets Nos. 54, 67, 68 and 69, Halifax county, N.S., and has traced several plans for office and field use. He left for the field with Mr. W. J. Wilson on May 24, and since his return has plotted his summer's work for the Summary Report, and resumed the compilation of Mr. E. R. Faribault's surveys on sheets 67 to 71, N.S.

Mr. P. Frèreault has compiled additions to Grenville sheet,—sheet No. 121, Ontario and Quebec,—and to the three sheets of Mr. A. P. Low's map of the east coasts of Hudson Bay and James Bay. He has made tracings and colour copy for the printing of the above maps, as well as for the West Kootenay sheet, the east Kootenay map, B.C., and the Victoria Mines map, Sudbury District, Ont.

Mr. Frèreault spent some time on sheets Nos. 16 and 17, Nipigon district, Ont.; prepared a list of Hudson Bay and Ungava District names for the Geographic Board, and attended to general draughting work.

Mr. V. Perrin has been engaged with Mr. McInness, in plotting this officer's surveys covering Ignace sheet—No. 5, Western Ontario series—has traced a portion of sheet No. 59 N.S. for engraving, and attended to general work, cataloguing plans and maps, &c. He has drawn for photo-lithographing a map of the Gaspé oil-fields, Quebec.

The following maps have been compiled by field officers from their respective surveys :—

Map of Ekwan and Trout rivers, Keewatin, scale 8 miles to 1 inch,* and Orographic map of Turtle mountain, Manitoba, scale 1½ miles to 1 inch, by Mr. D. B. Dowling.

Plans of the following Gold districts of Nova Scotia, by Mr. E. R. Faribault :— Mapping by field officers.

Isaacs Harbour, Guysborough county, scale 500 ft. to 1 inch.
Cochrane Hill, Guysborough county, scale 500 ft. to 1 inch.
Wine Harbour, Guysborough county, scale 400 ft. to 1 inch.
Harrigan Cove, Halifax county, scale 400 ft. to 1 inch.
Tangier, Halifax county, scale 250 ft. to 1 inch.

* This map has been incorporated in map No. 814, which accompanies the present Summary Report.

South Uniacke, Halifax county, scale 250 ft. to 1 inch.

Lake Catcha, Halifax county, scale 250 ft. to 1 inch.

Montague, Halifax county, scale 250 ft. tol inch.

Gold River, Lunenberg county, scale—-ft. to 1 inch.

Geological sketch map of the Blairmore-Frank coal-fields, Alberta, scale 180 chs. to 1 inch, by Mr. W. W. Leach.

Dr. A. E. Barlow compiled his surveys of the Sudbury mining region on a scale of 40 chains to 1 inch. His map which consists of two sheets, has however been prepared in this office for engraving and printing on the scale of 1 mile to 1 inch. The Victoria Mines portion has been engraved, and the Sudbury sheet is almost ready for engraving.

Another map of part of Sudbury district,—the map of Copper Cliff Company's mines, of a special character, is also under preparation by Dr. Barlow.

New surveys of the chains of islands along the east coast of Hudson bay, have been supplied by Mr. A. P. Low, and incorporated in his map.

Nova Scotia sheets.

The following sheets of the set of geological sheets of Pictou and Colchester counties, N.S., upon which the engravers resumed work last March, after having been for a long time held back on account of certain geological points requiring final investigation, were received from the King's Printer, namely :—Sheets Nos. 43, 44 and 45.

Sheet No. 57 has been signed for printing, and there still remain sheets 46, 47, 48, 56 and 58 in the hands of the printer, but it is hoped that most of these will be received within a short time.*

Dominion map.

The edition of the western half of the general geological map of the Dominion has been issued and distributed. It is only on the 8th of August, however, that the map could be delivered to this department, the lithographer, in December, 1901, notwithstanding previous delays and without the knowledge or permission of this department, having wiped off all the colour stones, had to spend considerable time in doing this work anew.

The colour copy for the eastern half of this map is in progress.

* Since writing the above, the remaining sheets have been received from the printer.

The regular meetings of the Geographic Board have been attended and lists of names covering the east coasts of Hudson Bay and James Bay, the northern interior of the Labrador peninsula and the Grenville sheet (sheet 121, Ont. and Que.) have been prepared and submitted to the board for discussion and decision. Another list of a few hundred names for sheets Nos. 59 to 62, Nova Scotia, is also under preparation. Geographic Board.

The following ten maps accompany the present Summary Report and illustrate part of the progress made in the field during the past summer:— Accompanying maps.

No. 810.—The Dominion of Canada, showing the progress of investigation by the Geological Survey of Canada, 1843 to 1903. Scale 250 miles to 1 inch.

No. 805.—Yukon Territory.—Explorations on MacMillan, Pelly and Stewart rivers. Scale 8 miles to 1 inch.

No. 808.—Alberta District.—The Blairmore-Frank coal-fields. Scale, 180 chains to 1 inch.

No. 804.—Manitoba.—Orographic map of lower contour of Turtle mountain. Scale, 1½ miles to 1 inch.

No. 809.—Ontario.—Shore lines of Ancient Great Lakes. Scale, 24 miles to 1 inch.

No. 814.—Ontario and Keewatin.—Explorations south-west of James bay. Scale, 16 miles to 1 inch.

No. 802.—Quebec.—Sketch map of Gaspé oil-fields. Scale, 2 miles to 1 inch.

No. 812.—Nova Scotia.—Preliminary Geological map of Springhill coal-field. Scale, 50 chains to 1 inch.

No. 806.—Nova Scotia.—Transverse vertical section of Blue-nose gold mine.

No. 801.—Prince Edward Island.—Geological outline map of P. E. Island, showing anticlines. Scale, 16 miles to 1 inch.

Maps, etc., published.

A list of maps, plans, diagrams, etc., which have been received from the printer during the calendar year, is appended herewith :—

Catalogue Number.	Description.	Area in Square Miles.
783	General geological map of the Dominion of Canada—Scale, 50 miles to 1 inch (western sheet).	
742	British Columbia—Geological and topographical map of Atlin mining district—Scale, 4 miles to 1 inch..........	814
771	" —Geological and topographical map of a portion of East Kootenay district—Scale, 4 miles to 1 inch. Preliminary edition	4,958
767	" —Geological and topographical map of Crows Nest coal-fields—Scale, 2 miles to 1 inch. Preliminary edition......	
766	Saskatchewan, Athabaska and Keewatin—Geological map of a portion of these districts (Grass river map)—Scale, 8 miles to 1 inch.....	41,360
777	Quebec—Geological and petrographical plan and sections of Shefford mountain, Shefford Co.—Scale, 40 chains to 1 inch......................................	47
785	Ungava—Sketch map of northern portion of Labrador peninsula—Scale, 50 miles to 1 inch. Corrected edition of map No. 758........	
598	Nova Scotia—Sheet No. 43 (Stellarton sheet), Pictou Co. —Scale, 1 mile to 1 inch	216
600	" Sheet No. 44 (New Glasgow sheet), Pictou Co.—Scale, 1 mile to 1 inch.......... ...	216
	" Sheet No. 45 (Toney river sheet), Pictou Co.—Scale, 1 mile to 1 inch.............	216
765	" Lake Catcha gold district, Halifax Co.—Scale, 250 feet to 1 inch............	
763	" South Uniacke gold district, Hants and Halifax Cos.—Scale, 250 feet to 1 inch...	
	Also seven diagrams to illustrate the Mineral Production of Canada, and seven zinc-cut illustrations for report No. 797, a special publication on the Cambrian Rocks of Cape Breton island.	

Maps in progress.

Besides the maps accompanying the Summary Report, 1902, there are nineteen maps in the hands of the King's Printer, and about thirty-five more, the compilation of which is at various stages of progress.

Field instruments.

The examination and repairing of field instruments has been attended to. Several worn-out prismatic compasses, tapes, barometers, etc., have been replaced. The following instruments were purchased :—

One microscope, No. 6, with attachments and set of objectives, from R. Fuess, Stiglitz, Germany. Field instruments.

Four prismatic compasses and tripod heads, Nos. 67–70, from Cary, London, Eng.

Five surveying aneroid barometers, Nos. 64–68, from Harrison & Co., Montreal.

Six pocket clinometer-compasses, Nos. 1–6, from Keuffel & Esser Co., New York.

One telescope for solar compass, No. 11, from W. & L. E. Gurley, Troy, N.Y.

Eight pocket compasses, Nos. 33–40, from T. Shore, Ottawa.

Eight pocket thermometers, Nos. 20–27, from Keuffel, & Esser Co., New York.

Two 100-ft. Chesterman metallic tapes, from Department of Stationery, Ottawa.

One 25-foot Chesterman metallic tape, from Department of Stationery, Ottawa.

Six taffrail boat logs, from G. Ashton Kay, New York.

One 50 foot steel band, No. 25, from Keuffel & Esser Co., New York.

The number of official letters, specification sheets, memoranda, etc., sent and received was 344 and 204 respectively. Correspondence.

PALÆONTOLOGY AND ZOOLOGY.

Dr. J. F. Whiteaves.

Dr. Whiteaves reports that the manuscript of part V, of volume I, of 'Mesozoic Fossils,' which was commenced in September, 1901, was completed on November 5, 1902, and that an index to the whole volume has subsequently been prepared. This part, which it has taken the greater part of three weeks to see through the press, as now printed, consists of 107 pages royal octavo of letter-press, illustrated by thirteen text figures and twelve full-page lithographic plates. Its preparation has necessitated the examination and critical study of seven additional collections from the Cretaceous rocks of Vancouver, Texada and Lasqueti islands, kindly forwarded by Mr. Harvey of Nanaimo, V.I. For the description of seven of the ten species of crustacea enumerated and illustrated in it, the writer is indebted to the kindness of Dr. Henry Woodward, F.R.S. The volume of which it forms the concluding part, now consists of 416 pages of letter-press, illustrated by twenty-nine text figures and fifty-one lithographic

plates. It may be described as a series of illustrated papers on the fossils of the Cretaceous rocks of the Vancouver and Queen Charlotte islands, in which 252 species are either identified or described.

A preliminary study has been made of the rather extensive collections of fossils from the Silurian rocks of the Ekwan river and Sutton Mill lake, made by Mr. D. B. Dowling in 1901, and a paper descriptive of two new species of *Trimerella* from these rocks has been published in the 'Ottawa Naturalist' for October last. About fifty species of marine invertebrata are represented in these collections, most of which are apparently new to science.

The collections of fossils made last summer, by Mr. D. B. Dowling, from the Laramie deposits near Roche Percée, Assiniboia, of fish remains from the supposed Niobrara shales at Arnold, Manitoba, and from the Silurian limestone at Stonewall, Manitoba; and those made by Mr. W. W. Leach, from the Laramie and Cretaceous rocks of the the Old Man river, Alberta, have been subjected to a preliminary examination, and their geological horizons approximately indicated.

The collections of fossils made last summer by Dr. R. A. Daly from the Palæozoic rocks at different localities in the Chilliwak river valley, have been studied, and some notes on these fossils have been prepared for Dr. Daly.

Collections of fossils, from the Devonian rocks of the Kwataboahegan, Moose and Abitibi rivers, and from the Pleistocene deposits at eight different localities on the Kapiskau, Kwataboahegan and Abitibi rivers, made by Mr. W. J. Wilson last summer, have been examined, and a list of the species represented in them has been supplied, for incorporation in his forthcoming report.

Seven small consignments of fossils from the Corniferous limestone near Amherstburg, Ontario, forwarded by the Rev. Thomas Nattress, have been studied, and the species represented in them have been named as far as practicable. One of these species, which apparently belongs to the genus *Panenka* of Barrande, and to a previously uncharacterized species of that genus, has been described and figured in the 'Ottawa Naturalist' for March last. It is the second species of *Panenka* that has been recognized in the Devonian rocks of Canada.

A preliminary examination and study has been made of a large series of fossil Cephalopoda from the Birdseye, Black river and Trenton formations at several localities in the immediate neighbourhood of Ottawa, kindly forwarded by Mr. Walter R. Billings.

A few fossils from the country south of Abitibi lake (apparently from small boulders), and from near Fernie, B.C., have been examined and some notes on them forwarded to the senders.

In September last eight days were spent with Dr. Ells in examining some rock exposures near Brockville, on Howe island, at Rudd's quarry, near Kingston, and at the cutting of the Grand Trunk railway near Kingston Mills. At this latter locality quite an interesting little collection of fossils was made, including some specimens showing the posterior apical termination of an apparently undescribed species of *Nanno*. These fossils would seem to show that the geological horizon of the rocks from which they were obtained is that of the lowest part of the Black River formation underlying the limestone. The palæontological and zoological collections in the museum of Queens University, Kingston, were also examined, as were also the private collections of fossils, etc., of Mr. Werden at Cherry valley, near Picton, and of Mr. Chadd, at Trenton. In the museum of Queens three specimens of the typical '*Lituites undatus*,' (Emmons) were noticed, and one of these has since been acquired for the museum of the Survey.

At the request of Section IV. of the Royal Society of Canada, a bibliography of Canadian Zoology for the year 1901 has been prepared and presented at its last meeting, for publication in its transactions.

Six short papers, descriptive of some of the latest additions to the zoological collections in the museum, have been written and published in the 'Ottawa Naturalist' for February, June, July, October and November, 1902.

About the usual number of letters, asking for information upon palæontological, zoological and other topics, have been received and answered.

The following specimens have been received from members of the staff, or employees of the department, during the year 1902 :—

Hugh Fletcher :—

Five specimens of fossiliferous shale from Messenger brook, near Kingston station, N.S.

Dr. R. W. Ells and J. F. Whiteaves :—

Two small collections of fossils from Ontario ; one from Rush bay, Howe island, and the other from the railway cutting at Kingston Mills.

Dr. H. M. Ami :—

About fifty specimens of fossils from the Pleistocene concretionary nodules at Besserers, near Ottawa; and one specimen of *Trocholites Canadensis*, Hyatt, from the Black River limestone at the Montmorency river, P.Q.

D. B. Dowling :—

Forty fossils from the Lignite Tertiary at Roche Percée, Assiniboia; thirty from the Cretaceous rocks at the Pembina river, Manitoba; seventeen from the Niobrara shales at Arnold, Manitoba; and twenty from the Silurian (Upper Silurian) rocks at Stonewall, Manitoba.

W. J. Wilson & O. O'Sullivan :—

110 fossils from the Devonian rocks of the Kwataboahegan and Abitibi rivers, and Piskwochi point, James bay.

Twenty specimens of fossil plants from the Pleistocene deposits of Abitibi river, and 165 Pleistocene fossils from the valleys of the Kapiskau, Kwataboahegan and Abitibi rivers.

W. W. Leach : –

Twenty five specimens of fossil shells and six of fossil plants from the Laramie and Cretaceous rocks of the Old Man river, Alberta.

W. Spreadborough :—

329 birds and small mammals from the boundary region between the Kettle and Columbia rivers, B.C.

The additions to the palæontological, zoological, ethnological and archæological collections in the museum during 1902 and from other sources are as follows :—

By presentation :—

(A.—Palæontology.)

Col. C. C. Grant, Hamilton, Ont.:—

Twenty-nine fossils from the Silurian rocks at Hamilton, five from the drift of Winona, and two from the drift at Burlington Heights.

T. C. Weston, Quebec City :—

Fossil coral *(Tetradium fibratum)* from Lorette falls, P.Q.: one specimen each of *Lingula Quebecensis*, Billings, and *Elkania desiderata* (Billings) from Point Levis, P.Q.

M. P. Davis, Ottawa :—

Specimens of fossil wood from excavations in the bed of the St. Lawrence river, in caisson for south main pier of the Quebec Bridge, Victoria cove, Sillery. Also samples of the materials from different depths and portions of the caisson of the same pier.

Rev. Thos. Nattress, Amherstburg, Ont.:—

Cast of the interior of the body chamber of a large specimen of *Gyroceras Numa*, Billings, from the Corniferous limestone near Amherstburg.

J. E. Narraway, Ottawa :—

Small piece of Black river limestone from Tetreauville, P.Q., with four heads of *Illœnus angusticollis.*

Lawrence J. Burpee, Ottawa :—

Fossil plant (? *Lepidodendron clypeatum*, Lesquereux) and piece of fossil wood (*Cordaites materioides*, Penhallow) from Casey point, Shediac bay, N.B.

Daniel McKenzie, Fernie, B.C. :—

Eight specimens of fossiliferous limestone from near Fernie.

David Armit (per D. B. Dowling) :—

Specimen of *Spirifer pennatus*, Atwater (= *S. mucronatus*, Conrad) from the Albany river shales.

(B.—*Zoology.*)

J. J. Carter, Ottawa :—

Flying squirrel, from Mariposa township, Victoria county.

W. S. Odell, Ottawa :—

Star-nosed mole, and two weasels, in summer fur, all from Ottawa East.

Rev. C. J. Young, Sharbot lake, Ont. :—

Male Arctic three-toed woodpecker, from near Sharbot lake.

Nest and set of four eggs of the Maryland yellow-throat, from near Lansdown, Ont. ; and set of three eggs of the Herring Gull, from Pine lake, County Frontenac, Ont.

Edwin Beaupré, Kingston, Ont. :—

Female black-breasted plover, from Amherst island, and photos. of the nesting places of four species of Canadian birds.

Set of five eggs of the American Bittern, from Cataraqui Marsh; and abnormally small egg of the Kingbird, from Napanee.

R. W. Tufts, Wolfville, N.S. :—

Two full sets of eggs of the house sparrow, and two of the barn swallow, from Wolfville.

A. P. Lov . -

Specimen of the Hudson Bay Lemming *(Dicrostonyx Hudsonius)* from the east coast of Hudson bay.

David McFarlane, Sand point, Ont. :—

Black chipmunk taken at Norway Bay Park.

Lawrence Watson, Charlottetown, P.E.I. :—

Five small pieces of red sandstone with burrows of *Petricola pholadiformis.*

L. M. Lambe, Ottawa :—

Little brown bat (male) from Ottawa.

W. E. Saunders, London, Ont. :—

Sixteen specimens of Unionidæ from Chatham, Ont.

J. Smith, Ottawa :—

Ball of Buffalo hair (probably from stomach of buffalo) found in prairie at Alberta, by J. E. Woods.

(C.—*Ethnology and Archæology.*)

R. W. Brock, Kingston, Ont. :—

Two stone pestles from the north fork of Kettle river, B.C.

A. P. Low, Ottawa :—

Twenty-five specimens of arrow heads, spear heads, chipped flints, sound, east coast of Hudson bay.

and fragment of a stone lamp, from ancient camps, Hopewell

Alfred Stirton, Spencerville, Ont. :—

Ten specimens of fragments of pottery and bone implements from Indian graves and mounds, about two and a half miles east of Spencerville, found eighteen inches below the surface of the ground.

G. B. Greene, Ottawa :—

Stone pipe bowl, with a carved figure of bird found on the south side of the Ottawa river, opposite Aylmer.

T. C. Weston, Quebec City :—

Four bullets from the Plains of Abraham.

Dr. C. F. Newcombe, Victoria, B.C. :

Two water-colour sketches of Chief Weed's house at Masset, B.C., by W. Chapman.

By exchange :—

Fine specimen of *Eurystomites* (?) *undatus* (Emmons), from the Black River limestone at Kingston.

By purchase :—

Two specimens of the Golden Eagle from near Kingston, Ont.

Two full sets of eggs of the Golden-crowned Kinglet, and one set each of the Northern American Raven, Rusty Blackbird, Acadian Sharp-tailed Sparrow, and Red-breasted Nuthatch ; all from Nova Scotia.

Palæontological Work.

Mr. Lawrence M. Lambe.

Mr. Lawrence Lambe reports as follows :—

The first half of the year was spent in a continuation of the study of the vertebrate fauna of the Belly river series of the Cretaceous of the North-west as represented, principally, by my collections in the Red Deer River district in 1897, 1898 and 1901.

Publication of memoir on vertebrates.

The result of this study, begun in 1900, in co-operation with Professor Henry Fairfield Osborn, appeared early in September in the form of a memoir : 'On vertebrata of the Mid-Cretaceous of the North-west Territory,' forming the second part of volume III (quarto) of Contributions to Canadian Palæontology.

Description of a new cretaceous fauna.

This memoir, following the late Professor Cope's first part on 'The species from the Oligocene or Lower Miocene beds of the Cypress Hills,' is descriptive of the fauna of the Belly river series that includes fishes, batrachians, reptiles and mammals. It consists of an introductory section by Professor Osborn on the 'Distinctive charac-

ters of the Mid-Cretaceous Fauna', followed by a descriptive section by myself on 'New Genera and Species from the Belly river series (Mid-Cretaceous)' illustrated by numerous text figures and twenty-one plates.

The general conclusion regarding the age of the Belly river fauna, as expressed by Professor Osborn, is that it 'is more ancient in character both as to the elder types of animals which it contains and as to the stages of evolution among animals which are also represented in the Laramie. The geological interval represented by the Ft. Pierre-Fox Hills marine beds was accompanied by the extinction of certain Jurassic types and progressive evolution of the persistent types. Finally, the fossil vertebrates hitherto described from Montana probably are, in part at least, of Mid-Cretaceous or Belly river age.'

The determination of a definite fauna of Belly River age adds greatly to our knowledge of the terrestrial life of Mid-Cretaceous times and helps, very considerably, to bridge over the gap that has hitherto existed between the varied land fauna of the Upper Jurassic and that of the Laramie.

To quote from a recently published review of this memoir 'the fauna described by Mr. Lambe is chiefly of land and fresh-water groups; some marine types, however, are present. There are thirty-four species represented, of which nearly half are new to science. Turtles, especially *Trionyx*, are very abundant. The Dinosaurs are the largest and most important part of the fauna. The slender, long-limbed and long-tailed, swift running types are represented by a large species of *Ornithomimus* estimated at twenty-two feet in length. The most characteristic Dinosaur are of the Iquanodout or duck-billed, and Ceratopsian or horned groups; these show various primitive features when compared with the corresponding forms in the true Laramie. *Stereocephalus* is a new genus of Stegosaur or plated Dinosaur with very massive skull armour and protective bony rings around the neck, which very much suggest the tail armature of the Edentale *Glyptodon*. Two mammals are also described, a rare discovery in any Mesozoic formation.'

Turtles.

Dinosaurs.

Mammals.

Much time has been given to the cleaning, the putting together and setting up many of the specimens preparatory to studying them. The preparation of drawings for the text and plate illustrations has also occupied considerable time. The latter part of the summer was devoted principally to seeing the above report through the press, and since then a catalogue, with a running number, of all the vertebrate remains from the Red Deer River district has been completed.

The majority of the specimens representing the Belly River fauna, among which are a large number of types, are now ready to be placed on exhibition, but unfortunately there is no space available, at present. for such a purpose, in the museum of the Survey. No museum space for exhibition of new types.

In April Professor Osborn visited Ottawa in connection with the work on the Red Deer river vertebrata, and later in June I was afforded the opportunity of spending a week in New York for the purpose of studying the Cope collections at the American Museum of Natural History.

During October and part of September drawings were made for plates XLII to LI, both inclusive, illustrating part V, volume I. of Mesozoic Fossils.

Collections of fossils, principally corals, have been determined and named for certain officers of the department for use in their reports.

The latter part of the year has been devoted to a critical study of some important and interesting vertebrate remains representative of the Edmonton fauna of the Cretaceous of the North-west.

Natural History of the International Boundary (49th Parallel).

Mr. James M. Macoun.

During the winter and spring months of 1901–2, such time as could be spared from my work as assistant to Prof. Macoun, was devoted to examining and determining the botanical and other natural history specimens collected near the International boundary in 1901. This work was far from completion when I again went to the field in 1902 and there are still many specimens to be determined. The material collected in 1902 has not yet been touched. Many new species of plants were collected in 1901, descriptions of which have been published in 'The Ottwa Naturalist' and elsewhere. Office work.

When I learned late in April, 1902, that I was to work on the International boundary west of the Columbia river, I at once communicated with Mr. W. Spreadborough who has for so many years acted as my assistant in the field. Mr. Spreadborough being willing to give up the work upon which he was then engaged, I directed him to proceed to Trail, on the Columbia river, a few miles north of the International boundary. He reached there early in May and began Work on International boundary.

at once to collect birds, mammals and plants, making full notes on the migration and nesting habits of the birds.

Join Mr. Spreadborough.

Being delayed in Ottawa reading proofs of the Catalogue of Birds I did not join Mr. Spreadborough at Trail until June 12. After examining the specimens collected by Mr. Spreadborough, I spent a few days in the vicinity of Trail that I might obtain a thorough knowledge of the plants of that region as they grew. It may be here stated that both Mr. Spreadborough myself had collected in the Columbia valley in 1890, when Prof. Macoun studied the flora and fauna of the Kootenay district. During the time we were at Trail, Mr. W. T. O'Hara, whose party I was later to join, was working between Midway and the Simillkameen river. Mr. O'Hara moved so rapidly across this part of the country that it was not thought advisable to have Mr. Spreadborough accompany him as there would be neither time to make large collections nor to properly prepare the specimens. This dry region is one of the most interesting parts of British Columbia from a natural history point of view, and will require to be thoroughly examined before any general report can be written on the country crossed by the International boundary. This examination should be made in May and June as spring and summer come a month earlier than farther to the east and west.

Flora and fauna of Cascade region.

On June 24, Mr. Spreadborough and I went west to Cascade, where we were joined a week later by Mr. O'Hara's party. We remained at Cascade until July 5, when the whole party started east along the Dewdney Trail. The fauna and flora of the region about Cascade differs widely from that of the Columbia valley as at Cascade the drier country is touched. It is, in fact, the point at which the plants characteristic of the Columbia valley mingle with those of the arid region west of Cascade.

Results.

The remainder of the summer was spent between Cascade and Waneta, at which point the Columbia river crosses the International boundary. The progress of Mr. O'Hara's party being necessarily slow, frequent side trips were made by Mr. Spreadborough and myself for which the requisite transport and supplies were furnished me by Mr. O'Hara. Every high mountain within reach was climbed and though a few species new to science and others new to Canada were collected the results of the summer's work in this respect were somewhat disappointing. This is due in part to the fact that except in the valley of the Kettle river at Cascade, there was no change in the character of the country examined, and, partly because practically the whole region traversed had been surveyed at one time or another by

members of the Geological Survey staff who had brought home with them botanical and other specimens. It was nevertheless necessary that a thorough examination should be made of the country between the Kettle and Columbia rivers, and from the data collected last season a complete report can now be written. As soon as the snow fell on the higher mountains I returned to Ottawa, leaving Mr. Spreadborough to continue the work east of the Columbia river. He remained with Mr. O'Hara until the end of the season and added many specimens of birds and mammals to those already collected. Following my instructions, he paid special attention to cryptogams, the flowering plants there being out of season. I cannot write in terms of too high praise of Mr. Spreadborough's untiring energy as a collector and it would have been impossible to attain anything like such good results without his assistance.

Mr. Spreadborough's work most satisfactory.

Mr. O'Hara afforded me every needed facility for moving about the country, and my relations with him and with Dr. Daly who accompanied the party as geologist, left nothing to be desired.

The Library.

Dr. John Thorburn, Librarian.

During the past fourteen months, from November 1 to December 31, 1902, there have been distributed 13,910 publications of the Geological Survey, comprising reports, parts of reports, special reports and maps. Of these 10,224 were distributed in Canada; the remainder (3,668) were sent to foreign countries as exchanges to universities, scientific and literary institutions and to a number of individuals engaged in scientific pursuits.

The sales of publications during the above period, including reports and maps, numbered 4,735. The amount received since the publication of the last report, was $641.79.

There were received as donations or exchanges 3,554 publications, including reports, transactions, proceedings, memoirs, periodicals, pamphlets and maps. Besides these, there were purchased 74 publications. The number of periodicals subscribed for was 40. The number of volumes bound was 260. The number of letters received in connection with the library was 2,252. The letters sent out by the library were 1,897. The number of acknowledgments received was 3,655, and there were sent out 740 acknowledgments from the library.

There are now in the library about 13,200 volumes, besides a large collection of pamphlets. Unfortunately, as has been frequently repeated in previous reports, the space available for library purposes is altogether insufficient, and causes a large amount of unnecessary labour in finding information asked for. It is to be hoped that some provision may be made soon to remedy this.

Visitors to the Museum.

The number of visitors who signed the museum register during the year was nearly the same as in 1901, namely 37,728.

Staff, Appropriation, Expenditure and Correspondence.

The strength of the staff at present employed is 56.

There were no changes in the permanent staff during the year.

The funds available for the work, and the expenditure of the department during the fiscal year ending 30th June, 1902, were :—

Details.	Grant.	Expenditure
	$ cts.	$ cts.
Civil-list appropriation	55,200 00	
General appropriations	68,730 00	
Civil-list salaries		48,856 44
Exploration and survey		22,048 36
Wages of temporary employees		23,311 38
Printing and lithographing		16,841 73
Purchase of books and instruments		1,401 51
" chemical apparatus		213 60
" specimens		376 15
Stationery, mapping materials and King's Printer		1,396 87
Incidental and other expenses		2,591 68
Advances to explorers		14,782 99
		131,820 71
Deduct paid in 1900-01 on account of 1901-02		14,234 27
		117,586 44
Unexpended balance Civil-list appropriation		6,343 56
	123,930 00	123,930 00

The correspondence of the Department shows a total of 7,860 letters sent, and 11,239 received.

I have the honour to be, Sir,

Your obedient servant,

ROBERT BELL,

Acting Deputy Head and Director.

GEOLOGICAL SURVEY OF CANADA

ROBERT BELL, M.D., D.Sc., LL.D., F.R.S., I.S.O.

SUMMARY REPORT

ON THE

OPERATIONS OF THE GEOLOGICAL SURVEY

FOR THE YEAR 1903

BY

THE DIRECTOR

OTTAWA
PRINTED BY S. E. DAWSON, PRINTER TO THE KINGS' MOST EXCELLENT MAJESTY
1904

No. 866

TABLE OF CONTENTS

SUMMARY REPORT

ON THE OPERATIONS OF

THE GEOLOGICAL SURVEY OF CANADA

FOR THE CALENDAR YEAR 1903.

The Honourable CLIFFORD SIFTON, M.P.,
Minister of the Interior,
Ottawa.

SIR,—I have the honour to submit the following Summary Report on the affairs of the Geological Survey Department for the calendar year 1903. It will be found to contain an account of all the operations carried on by the Department, both at head-quarters in Ottawa and in the field. As in previous years, it has been the constant aim of the Survey to meet the expectations and requirements of the public in conformity with the provisions of the Act governing the Department, and to give an economic and practical character to all its labours.

Principal work of the Survey.

The Survey carried on, as usual, a certain amount of palæontological, zoological, botanical, ethnological and archæological investigations, for all of which it enjoys, incidentally, considerable advantages which it is desirable to utilize in the interest of science; but by far the largest proportion of our work is directed to investigating and aiding the development of the mineral resources of the country. With this end in view, the field-operations each year are spread over all the provinces and most of the territories of the Dominion, while the indoor work consists of chemical, mineralogical and lithological researches, drafting and mapmaking in all branches, preparing reports, bulletins on economic materials and other special publications, the keeping of accounts, collecting and tabulating statistics of mines and works in connection with mineral products of all kinds, the care of the library and the different branches of the museum and of our large stock of maps and field instruments, photography in connection with mapmaking, the artistic drawing of fossils, supplying collections of named minerals to educational institutions, the preparation and installing of collections of samples of the economic minerals and rocks of Canada

at exhibitions, sending out the reports, maps and other publications of the Survey, an extensive correspondence, attention to visitors on departmental business, etc. The editing and proof-reading of our publications occupies much of my time and that of the secretary, Mr. Percy Selwyn, who is very proficient in this work. Mr. Selwyn has also done good service in attending to the correspondence and other office duties during my absence in Europe and in the field.

Indispensable topographical work.

In the vast unsurveyed regions of Canada, which may be rich in economic minerals and therefore require investigation by the Survey, a certain amount of topographical work is indispensable in connection with the geological researches. The field-work of the Surveyor General of the Dominion and of the Commissioners of Crown Lands of the several provinces is mainly devoted to dividing up, by straight lines, the unoccupied lands best fitted for agriculture, and consequently, the least likely to be of value for economic minerals, and these officers have no object in causing surveys to be made of the more rocky and distant sections of the country. As it is in such regions that the work of the Geological Survey requires to be carried on, we are obliged to do the topographical work *pari passu* with the geological, in order to construct proper maps for the purposes of the Department. Therefore, the officers in charge of our field parties should be proficient surveyors as well as geologists.

The geological maps resulting from the combined topographical and geological field-work of the various members of the staff are plotted and compiled during the winter in the offices at Ottawa, by the same men who make the surveys, aided by the chief draftsman and several assistants.

Extraneous assistance.

During the season just closed, less help has been obtained from geologists outside of the Department than in the two previous years. Professor Ernest Haycock of Acadia College aided Dr. Ells in working out the geology of Charlotte county in New Brunswick. Mr. J. A. Dresser investigated the relations of copper ores to their enclosing rocks in the Eastern Townships of Quebec; Mr. G. A. Young has given us a report on the petrology of Yamaska mountain and Mr. Charles Camsell has contributed gratuitously some valuable information in regard to certain rocks and minerals in Manitoba. The fine geological map of the Pictou coal-field prepared in this office and which is nearly ready for publication by the Survey, is largely due to the labours of Mr. Henry S. Poole, extending through many years of practice as a mining engineer within the area represented. Mr. Poole has, with great liberality, given me, free of charge, except for some incidental

expenses, an able practical report on this coal-field to accompany the map. We are greatly indebted to Dr. F. D. Adams, Professor of Geology at McGill University, for a very valuable report on the artesian wells and underground waters of the Island of Montreal, which also contains additions to our previous knowledge of the geology of that island. This report is the result of a number of years' observation and collecting of information on the subject, and Dr. Adams has generously presented it for the use of the public, entirely free of charge. It is accompanied by carefully prepared tables of the 'logs' or records of borings and a geological map of the island and surrounding district. Dr. Adams was assisted in the field-work and in preparing the report by Mr. O. E. LeRoy, who was afterwards, for a time, connected with the Geological Survey.

FIELD WORK.

Field-work.

The field-work is, of course, the primary and most important of the duties assigned to the Geological Survey and all our other labours are consequent upon it. The various regions for the field operations of the season 1903 had been judiciously chosen as the results have shown. The several portions of work done have proved to be those most needed to meet present requirements. All the men sent to the field were competent to carry out their instructions and the aggregate of new information on geography, geology and a variety of other useful subjects has added greatly to our knowledge of Canada. Everyone employed was advised to exercise great care and as a consequence no misfortunes or 'accidents' of any kind occurred.

In the following brief review of the work accomplished the various regions exploited are arranged, as before, in order from northwest to southeast across the continent.

Yukon district.

In the Yukon district, Mr. R. G. McConnell, without a professional assistant, completed the work which was intended to be done for the present in the Klondike gold mining area. This consisted in tracing out the boundaries of the different rock-formations on the ground and laying them down upon a contoured topographical map which he had prepared in previous years, by the aid of Mr. Frank Johnson and Mr. Joseph Keele. Mr. McConnell, while performing his geological work in this district, also kept in view the desirability of establishing a water-supply for common use in placer mining in the future, and he has prepared an elaborate statement on the subject for the information of the commissioners who were appointed by the government last summer to investigate this matter. The maintenance of a large pro-

duction of gold in this district in years to come depends principally on obtaining a better supply of water than is procurable at present. Mr. McConnell's investigations afford further evidence of the local origin of the gold of the Klondike area.

Lardeau district, B.C.

Work was begun in the Lardeau district in southern British Columbia by Professor R. W. Brock as geologist, and Mr. W. H. Boyd as topographer. The latter is engaged in constructing a map of this region. Very little had heretofore been known of the geology which appears to be of considerable interest. Promising discoveries of gold in veins have been made in the district

Peace river country.

The demand for reliable information as to the Peace river country increased considerably last year. With a view of ascertaining the true character of the land and the climate of the upper or western portion of this region, I requested Mr. James Macoun to undertake an investigation of as much as possible of the Peace river country in general, and the upper portion in particular. He was also to verify, or otherwise, the reports and opinions of others who had preceded him. Accordingly, he started as early as the season would permit, and since his return, has written a report which will be issued as soon as possible, as a special publication of the Survey, and may not appear in the Annual Report for the year, nor in the present Summary Report. Mr. Macoun was assisted by Mr. William Spreadborough.

Coal-field in Rocky Mts., near C.P.Ry.

The growing demand for a supply of coal near the line of the Canadian Pacific railway in the Rocky mountains required this Department to make a geological survey of the region around this section of the line and for a considerable distance to the southward, for the purpose of ascertaining the nature, geological relations and extent of such coal seams as were already known and of discovering others. Mr. D. B. Dowling, who was instructed to undertake this work, examined into the geology of the mountains on either side of the railway from Banff Hot Springs to The Gap or on both sides of the Cascade and Bow rivers, and since his return he has commenced carving to scale a model of this section, which will show artistically in colours the geological structure and the relations of the various strata which include the coal seams. Mr. Dowling, according to instructions, also explored for coal about the head-waters of Sheep creek and this duty was carried out successfully. He was assisted throughout the season by Mr. Fred Bell of Winnipeg.

Sheep creek

International boundary of B.C.

On the International boundary, which is being located along the 49th parallel in the western mountain region between British Columbia

and the State of Washington, Dr. R. A. Daly continued a geological examination on behalf of Canada. This work extended from the boundary, as a base, to an average distance of ten miles from it. His report will be found in the present volume.

Southern Keewatin.

To the southwest of Hudson bay, in the Severn district of the Hudson's Bay Company, which forms part of the vast tract now called Keewatin, there was, up to last year, a great unsurveyed area, through which the Winisk river flows. I requested Mr. William McInnes to undertake a combined topographical and geological survey of this large stream. This he accomplished very successfully with the aid of four Indians, but without any white assistance, and returned to Ottawa early in the autumn. The accompanying complete and concise report, in which he gives very interesting information on all subjects relating to the country traversed, demonstrates what may be accomplished in a short season by a single competent officer with a small party of aborigines.

Nagagami river.

One of the canoe-routes from Lake Superior to the Albany river crosses the height-of-land a short distance northward of Montizambert on the Canadian Pacific railway and follows the Nagagami river to its junction with the Kenogami at Mamma-wé-mattawa (The meeting of many waters). Mr. W. J. Wilson of this Department was instructed to make an instrumental survey of this route; also of the lower portion of the Kébinakagami river as far up as the point to which I had surveyed it downward in 1889, and of the Oo-sha-a-poo-ka-tick or Ridge river as far as it could be navigated by canoes. These two streams and also the Pagwitchewan fall into the Kenogami at the same place as the Nagagami. Mr. Wilson's party was also to survey the Drowning and Little Current rivers, which flow from the west and join the Kenogami between Mamma-wé-mattawa and The Forks of the Albany. Mr. Owen O'Sullivan acted as Mr. Wilson's assistant and these two gentlemen fully carried out my instructions, accomplishing all the work prescribed. They have plotted their surveys and are compiling a map on which they will be shown, together with parts of my own surveys of 1870, '77, '86 and '87.

Other branches of Kenogami river.

Tract behind Bruce mines.

In the country behind the Bruce mines, Mr. Theo. Denis, who had assisted Mr. Ingall there in 1902, continued the work for part of the season, assisted by Mr. Uglow. On leaving this field Mr. Denis visited the salt wells and works near Windsor, Ontario, in order to obtain some necessary information and Mr. Uglow was sent to assist Dr. Hugh Ells in finishing the Prince Edward county map-sheet.

Temagami region.

For the purpose of continuing the geological mapping of the Temagami lake region, I instructed Dr. Barlow to proceed with the survey

of the map-sheet adjoining the Temiskaming sheet, (No. 599) on the west, in which the geology would no doubt prove of much interest and where deposits of valuable minerals might reasonably be expected to exist.

Prince Edward county.

The Prince Edward county map-sheet (No. 110), most of which had been worked out by Dr. R. W. Ells, still required certain areas to be completed in Prince Edward and Hastings counties and Dr. Hugh Ells, who had previously assisted in the surveys for this sheet, was requested to do the necessary work for this purpose.

Surface geology in Quebec.

The Surface geology of the province of Quebec on both sides of the St. Lawrence especially between Quebec city and Montreal was not sufficiently well known and Dr. Chalmers was instructed to examine this region and collect all the information possible on this branch of its geology and also in regard to artesian borings within the same limits. He performed this duty without any assistant and his report shows that a large amount of work was accomplished.

Yamaska mountain.

The investigation of the geology and petrology of the various isolated hills of volcanic origin which stand out prominently on the level plains of the southern part of Quebec has been making progress for a number of years through the labours of several geologists. A description by Dr. J. A. Dresser of Shefford and Brome mountains was published in the Summary Report for 1901. During the past season Mr. G. A. Young was carrying on an examination of Yamaska mountain and in exchange for some aid extended to him, he has given us the short report on this mountain which is published herewith.

Copper in the Eastern Townships.

The exact mode of occurrence of the copper ores of the Eastern Townships in relation to the containing rocks, being a question of considerable economic importance in the practical geology of that region, Dr. J. A, Dresser has been engaged during the last two seasons in investigating this subject. His report, illustrated by a map, shows that the copper is confined to certain ancient volcanics to which prospecting should be confined.

New Brunswick.

Our knowledge of the geology of Charlotte county, New Brunswick, left much to be desired. Accordingly, I requested Dr. Ells to supplement it by further examination, in order to determine more certainly the boundaries of the formations and the geological ages of some of the rocks. He was assisted by Mr. R. A. A. Johnston, of this Department, and Professor Ernest Haycock, of Acadia College. Dr. Ells returned before the end of the season in order to re-examine some parts of the mica, graphite and phosphate regions, before preparing bulletins for publication on these economic minerals. Messrs. Johnston

and Haycock continued the work in New Brunswick till the close of the season.

Northern Nova Scotia.

The systematic detailed geological survey was continued in the northern part of the mainland of Nova Scotia by Mr. Hugh Fletcher and two assistants. The work of the season was confined principally to Annapolis, Kings and Cumberland counties. Mr. Fletcher also aided in the completion of Mr. H. S. Poole's report and map of the Pictou coal-field which are now ready for publication. Mr. Fletcher's geological researches connected with mapping and describing the geology of Nova Scotia have now extended over twenty-eight years, most of this time having been devoted to working out the structure of the various coal-fields. His work is highly appreciated by the coal-mining community and by every miner and practical geologist in the province, all of whom have the utmost confidence in the results he has arrived at, as set forth in his reports and the numerous maps which have been constructed by him from his own surveys.

Gold in Nova Scotia.

In connection with the large output of coal which is now going on in both Nova Scotia and Vancouver island, an interesting fact is worth mentioning, namely, that the only coal worth mentioning which is known to occur in North America on the immediate seaboard of either the Atlantic or Pacific, belongs to Canada.

The nature and arrangement of the gold-bearing veins of Nova Scotia have been further investigated by Mr. E. R. Faribault and two assistants, During the twenty years Mr. Faribault has been engaged in this work, he has produced twenty-four plans of the gold districts of the province, of which eighteen have been already published, three are ready for publication and the remaining three are in the engraver's hands. Mr. Faribault has also published numerous reports and papers on gold veins and gold mining and milling in Nova Scotia. He appears to have arrived at correct general conclusions as to the gold veins of the province and is now preparing a concise bulletin on the subject. He has just been invited by the government of the province to go to Halifax and advise it in regard to the pending legislation for the encouragement of deep mining for gold. His work has already been of great value in developing the gold resources of Nova Scotia by giving the mining of this metal a permanent character, due to a knowledge of the true nature of the veins and the assurance of a continued supply of ore.

Hudson Bay expedition.

Mr. A. P. Low of this Department was placed in command of the Hudson Bay Expedition in the SS. *Neptune*, which was commissioned to visit the shores of Hudson bay and strait and our islands lying to

the northward of the mainland of Canada on behalf of the Departments of the Geological Survey, Marine and Fisheries and Customs. Commander Low sailed from Halifax on the 22nd of August, with a total ship's company of 43. Besides having general charge of the expedition, he was instructed to make geological notes, especially with regard to any occurrences of economic minerals at all places which had not previously been visited by a geologist and more particularly at localities which could only be reached by a sea-going vessel. He was also to make surveys, if possible, during the winter, using the ship as a base of operations, and in summer in addition to other duties he was to investigate the fisheries and do whatever work he could in natural history and botany. Mr. C. F. King, of the Geological Survey, was sent as Commander Low's assistant for geology and biology. It was expected that the expedition would spend the winter in the northwestern part of Hudson bay. Interesting and important geological information will no doubt result from this expedition.

ROCK-SLIDE AT FRANK.

Rock-slide at Frank.

On the 29th of April a rock-slide of considerable magnitude took place from the face of the mountain overlooking the town of Frank, where the southern line of the Canadian Pacific railway enters the Crows Nest Pass through the Rocky mountains. The first telegraphic news of the disaster which reached Ottawa described it as a "volcanic eruption," but those who inquired as to its nature at the office of the Survey were immediately informed that this was exceedingly unlikely and indeed almost impossible. I telegraphed to Mr. W. W. Leach, who had worked in this locality for the Survey the previous season and who was then in the vicinity, asking him to telegraph me a sufficiently full description of the phenomenon. He complied with my request, and his description was immediately placed at the disposal of the press and printed in the leading newspapers.

CLAY-SLIDE ON LIÈVRE RIVER.

Clay-slide on Lièvre river.

A land-slide in the clay of the valley of the Lièvre river having taken place at Little Rapids on the morning of Sunday, 11th October, Drs. Ells and Barlow were requested to examine it as soon as possible after its occurrence, as phenomena of this kind are of some scientific and practical importance. Dr. Ells' report on what they saw is illustrated by a sketch-map and a photographic view of the ground that was affected.

AMYGDALOID IN MANITOBA.

Reference has been made to the discovery of amygdaloid rock in Manitoba by Mr. Charles Camsell. As to this subject, Mr. Camsell wrote me on the 28th of November as follows :— Amygdaloid in Manitoba.

'With regard to the occurrence of amygdaloid at the north end of Lake Manitoba, the beds are not very extensive and are easily covered by a claim of 1,500 feet square. Smaller areas occur to the south-east and north-west. They rise about ten feet above the general level of the plain to the east, which is low and swampy; while on the west they seem to dip under almost horizontal beds of gypsum. The amygdaloid also seems to be nearly horizontal. The dip, if any, is towards the west. The colour is usually reddish, but sometimes it is a dark purple. The cavities near the surface are nearly always empty and lined with a coating of a white substance. Occasionally they are filled with a greenish earth or with crystals of zeolites. Small particles of copper can be seen with the microscope and some copper carbonate.

'Small areas of a jasper conglomerate are associated with the amygdaloid but their relative position is uncertain.

'About seven miles to the south-east, on Sugar island in Lake St. Martin is an outcrop of crystalline trap rock, which Mr. J. B. Tyrrell describes, and which, from his assay, contains some copper, and this rock probably has some connection with the amygdaloid. East of this are small areas of coarse-grained granite surrounded by limestone.

DISCOVERY OF SILVER AND COBALT.

Late in the autumn, a discovery of silver and cobalt, which appears to be important, was made by men working on the line of the Temiscaming railway at Long lake, about five miles southward of Haileybury on the west shore of Temiscaming lake. The metals occur in veins, the silver, both native and as sulphide. The locality was visited by Professor W. G. Miller, Provincial Geologist of Ontario, just before it became covered by snow, and he considers the discovery to be one of much promise. The veins cut slatey rocks, apparenty belonging to the Animikie or lower Cambrian series which carries the silver ores of the Thunder Bay region. These rocks are reported to have been found also further north, around the base of the outlier of the Niagara formation which extends north-westerly from the head of the lake. If this should prove correct, there would be a prospect of finding other silver-bearing veins in this region, wherever these rocks occur. Discovery of silver and cobalt.

WORK AT HEADQUARTERS.

Work at headquarters.

In the present summary of the work done by the various officers of the Department will also be found reports on that performed by the different indoor or home members of the staff, namely, as to Chemistry and Mineralogy by Dr. G. C. Hoffmann, the Mines Section by Mr. E. D. Ingall, Mapping and Engraving by Mr. C. O. Senecal, Palæontology and Zoology by Dr. J. F. Whiteaves, Vertebrate Palæontology by Mr. Lawrence M. Lambe, Botany and Ornithology by Professor John Macoun and the Library by Dr. John Thorburn.

The reports, as to both the field and home work are printed as they were written by the various officers themselves, in order that they may thus obtain full credit for their labours.

In the chemical laboratory.

The usual amount of work has been done in our chemical laboratory in connection with the examination of economic minerals collected by the officers of the staff or brought or sent in by others, but owing to the establishment of good laboratories in connection with the mining bureaus of the different provinces, the amount of assaying which we are requested to do for prospectors is limited. Mr. Donald Locke, who had been appointed to do work of this kind, resigned on the 14th of September and Mr. M. F. Connor was appointed to succeed him.

Mining statistics.

As in former years, the mining section of the Department is preparing a preliminary statistical statement of the mineral production and the condition of the different branches of mining in Canada for 1903. The final details are only received from our correspondents after the close of the year and it is generally about the middle of February before the statement can be issued. This section has prepared its full report for 1902, which will be published in the course of a month or two. Besides a large amount of statistical tabulation, it contains chapters giving general information as to different economic minerals in relation to the Dominion. From this report it will be seen that Canada now produces a considerable variety of both metallic and non-metallic minerals, although it is within the recollection of many, that in the territory which now constitutes the Dominion, coal, building materials and a little iron ore were the only mineral products. At the time when the Geological Survey commenced active operations in 1843, a number of other economic minerals were known to exist, but only in small quantities. Since that time, and largely owing to the operations of the Survey and the information afforded by its reports, its museum and its showing of fine specimens of minerals at exhibitions at home and abroad, other economic minerals have been discovered in commercial quantities and more or less developed in about the follow-

Principal economic minerals of Canada.

ing order, historically: copper, coal and iron in larger quantities, lead, petroleum and natural gas, gold, iron-pyrites, gypsum, slate, cement-stones, salt, mica, graphite, apatite, silver, asbestus, feldspar, nickel, zinc, corundum, chromic iron and cobalt. In addition to these, a considerable variety of marbles, granites and other ornamental rocks, gems and semi-precious stones, peat, shell-marl, ochres and other materials used as paints have been discovered in many places.

The following minerals, mentioned in alphabetical order, are those which were most frequently inquired for during the year:

Minerals enquired for during the year.

Asbestus, borax, baryte, celestite, corundum, copper ores, chromic iron, feldspar, fire-clay, fluorspar, graphite, gypsum, iron-pyrites, iron sand, kaolin, monazite, magnesite, molybdenite, natural gas, peat, pottery clay, phosphate, soapstone, silica sand, talc, vanadium, wolfram, zinc ores.

Palæontology.

In the Department of Palæontology, the reports of Dr. Whiteaves and Mr. Lawrence M. Lambe show gratifying progress. The latter has completed for publication a work on *vertebrate* fossils from the North-west Territories, entitled 'Contributions to Canadian Palæontology,' Vol. III., (Quarto) Part II., illustrated by eight fine plates prepared by himself, which it is intended to reproduce by the Heliotype process in the same manner as the plates in his last volume on a similar subject. Professor Penhallow's paper on *Osmundites*, which was contributed to by this Department, was published during the year in Vol. XXI of the Transactions of the Royal Society of Canada.

Zoology.

The zoological work of the year has related principally to Ornithology. Dr. Whiteaves has added a number of sets of rare eggs to the collection of the eggs of Canadian birds already in the museum. Our large collection of bird-skins has been enriched by numerous additions. Professor Macoun has nearly completed his third and last volume on Canadian Birds and this important book is eagerly awaited by ornithologists all over the continent.

Botany.

In the Botanical Division, Professor Macoun's work was confined to the lower Ottawa valley and was devoted largely to the Fungi, of which he has now found no fewer than 1,100 species in this part of Canada. The 10 new species of violets of Prince Edward Island, discovered mostly by Mr. Lawrence W. Watson when employed by the Survey, have been described by Professor Green of Washington and figured by Dr. Theo. Holm of the same city. It is proposed to publish these descriptions and figures within a short time. The descriptions and figures of the ten new species of plants from Hudson bay are also ready for publication.

REPORTS, BULLETINS, SPECIAL PUBLICATIONS, ETC., WHICH HAVE BEEN ISSUED BY THE SURVEY DURING 1903.

Publications of the department in 1903.

Summary Report of the Geological Survey for the calendar year 1902, pp. 482, with 7 sections, 2 plates and 9 maps.

Part A, Vol. XV., with 9 maps, plates and sections by the geological corps.

Report on the Geology and Physical Characters of the Nastapoka Islands, Hudson Bay, Part DD, Vol. XIII., pp. 31, by A. P. Low.

Report on the Section of Chemistry and Mineralogy, Part R., Vol. XIII., pp. 67, by G. C. Hoffmann.

Section of Mines, Annual Report for 1901, Part S, Vol. XIV., pp. 160, by E. D. Ingall and J. McLeish.

Annual Report, Vol. XIII. (new series) 1900, English edition, pp. 747, with plates and maps.

Report on the Cambrian Rocks of Cape Breton, pp. 246 and 18 plates, by G. F. Matthew.

Catalogue of Canadian Birds, Part II, pp. 413, by John Macoun.

Mesozoic Fossils, Vol. I, Part V.. (and last). On some additional fossils from the Vancouver Cretaceous, with a revised list of the species therefrom. Illustrated by 12 plates, by J. F. Whiteaves.

Publications in two years.

Since January 1st, 1902, the Geological Survey Department has published 26 reports, which embrace the following subjects, viz. :—Geology and Geological Surveys, Palæontology, Botany, Zoology, Chemistry and Mineralogy, Mining and Metallurgy, &c. Within the same period the Department has also published 38 maps, both geological and topographical, besides 15 diagrams.

Maps.

The number of geological maps published within the calendar year 1903 was 27 and of diagrams, 15.

The 38 maps, above mentioned, are all of a superior character, both as to accuracy in what they represent and as to drawing and engraving. As mentioned in the report of the Geographer of the Department, in addition to the above, a considerable number of maps, some of them quite elaborate, are in various stages of preparation, and four of them are nearly complete. No map is engraved for the Department until sufficient field-work has been done to secure accuracy, and each new map must give enough fresh information to justify the expense of publication. In the colour-printing of geological maps, we have

Colour-printing.

greatly facilitated and cheapened the process for the production of any desired number of tints with a minimum of printings, by adopting a variety of patterns of parallel ruling in four directions and by over-printing these with different colours in various ways, after the manner of the 'three-colour system.'

PUBLICATIONS BY THE GEOLOGICAL SURVEY ON ECONOMIC MINERALS.

The leading feature in the work of the Geological Survey throughout its whole history has been the attention paid to mining and economic minerals. The publications of the Department devoted to this subject aggregate more than 600, besides about 400 maps. These are in the form of Reports of Progress, Annual Reports, Summary Reports, Special Reports on individual minerals, on coal-fields and other mining districts, on the Mineral Wealth of British Columbia and the Mineral Resources of the provinces of Quebec and New Brunswick, Bulletins on Economic Minerals, Handbooks on the same subject for use at exhibitions, full Descriptive Catalogues for the same purpose, etc., published throughout the whole existence of the Survey. A brief enumeration of these publications is given further on in the present report. In addition to issuing the various reports, etc., mentioned in this list, the principal officers of the Department have always endeavoured to keep the mineral wealth of Canada before the world by means of articles read before societies, institutes, associations, etc., or published in the scientific and technical journals, magazines and papers or in the Transactions or Proceedings of these bodies. The number of such articles has now reached more than 100, while the total number of the official publications of the Survey on economic geology, classified as above is over 600, as just stated. Publications on economic minerals.

Another chief means adopted by the Survey for bringing the mineral resources of Canada before the people of all nations, was by making fine displays of our mineral products at the numerous International Exhibitions which have been held, beginning with that of 1851, in England, Scotland, Ireland, on the continent of Europe and in different cities in the United States of America, at the Indian and Colonial Exhibition and at exhibitions held in Canada itself. At every one of these exhibitions, which were more or less competitive, it may be truly said that the Canadian exhibit was in every way the best. Our collections were always accompanied by full Descriptive Catalogues for free distribution which were themselves precise and excellent reports on the minerals of Canada. These valuable collections were on several occasions left for permanent exhibition in the cities to which they had been sent. Although special grants may have been made to Value of exhibitions.

help to defray the cost of collecting, transporting, installing and exhibiting these collections, still they were always a considerable cost to the Survey, both in money and the time of its officers. It is, therefore, marvellous that such great services could have been rendered the country at such a small cost, by the above-mentioned liberal publication, by striking displays of our economic minerals at so many International Exhibitions and in the Museum at headquarters, all simultaneously with the vigorous prosecution of the examinations of mining districts and of general geological and topographical surveying over half a continent, for the most part lying in a state of nature. The comparatively rapid progress which has been made, in spite of artificial hindrances, in the development of our mineral resources, now yielding upwards of $60,000,000 a year, is due to the above efforts more than to any other cause.

Promotion of development of mineral resources.

Publications on economics.

The reports of the Survey, having always been devoted mainly to economic geology, it was not considered necessary in the past to publish many separate reports on economic minerals, but as unavoidable delays are apt to occur in the issuing of our Annual Reports, which have now become large volumes requiring maps and other illustrations, it was decided to issue, at more frequent intervals, a part of the information formerly given in these or in other reports, in the form of separate publications, under the name of Bulletins on individual minerals, mining districts, &c., as they might be required from time to time, in order to keep the information thereon as to the whole Dominion constantly up to date.

Bulletins.

During the past year, bulletins of this kinds have been completed or are being prepared on the following subjects:—

Platinum; printed.	Pigments; in preparation.
Zinc; printed.	Shell Marl; printed.
Manganese; in press.	Mica; ready for press.
Molybdenum and Tungsten; ready for press.	Graphite "
Nickel; in preparation.	Apatite "
Asbestus; printed.	Peat "
Coal; in press.	Geology of the Klondike Gold District; in preparation.
Common Salt; in press.	Roofing slates; "
Infusorial Earth; in press.	Gold in Nova Scotia. "
Corundum; in preparation.	

Besides the above nineteen bulletins, the data are being assembled for others on the following subjects, also in reference to the whole Dominion: copper, iron, building stones, marbles, gypsum, iron-pyrites, stones suitable for making hydraulic cement, clays, bricks, tiles

and pottery, abrasives (other than corundum), petroleum and natural gas, gems, ornamental and semi-precious stones.

DOMINION OF CANADA INDUSTRIAL EXHIBITION.

Dominion exhibition, Toronto.

The manager and secretary of the Dominion of Canada Exhibition, Dr. J. O. Orr, having consulted me in regard to the possibility of having the economic minerals of the country properly represented at that exhibition, which was to be held in Toronto from the 27th of August to the 12th of September, I referred the matter to yourself and the Hon. Mr. Fisher, as everything pertaining to exhibitions had been transferred to the Department of Agriculture at the close of the Paris International Exposition of 1900. In this case, however, it was decided that the Geological Survey should make a suitable display at Toronto. This conclusion was reached barely four weeks before the collection required to be installed in the exhibition building. Mr. C. W. Willimott was asked to superintend the work, and the whole matter was very successfully carried out.

Character of mineral exhibit.

Our large and representative collection proved to be one of the most interesting features of the Exhibition and attracted great attention, not only from the Canadian visitors, but it was also very favourably commented upon by distinguished strangers from Europe and the United States. There is no doubt it did much good in calling attention to the great mineral wealth of Canada. It was awarded a diploma and gold medal. After the close of the Exhibition, the manager and secretary sent me the following letter :—

Letter from the manager.

'DOMINION OF CANADA INDUSTRIAL EXHIBITION,
TORONTO, Oct. 22, 1903.

'Dr. ROBERT BELL,
Geo. Survey Department,
Ottawa, Ont.

'MY DEAR DR.,—I have to thank you on behalf of the Board of Directors of the Association for the magnificent exhibit which you sent to our Exhibition. We located it adjoining the display of the Jubilee Presents. Every one was loud in their praises, and expressed their astonishment that we possessed such rich and valuable minerals.

'We cannot express too highly our appreciation to Mr. Willimott, for his devoted attention to the exhibit at our Exhibition. His arrangement of the exhibit was all that could be desired, and the information given by him to the inquiring public was greatly appreciated. Without a doubt the exhibit was a feature of the Exhibition, and the Jury on awards have awarded the Exhibit a Gold Medal and Diploma.

'I am writing the Hon. Mr. Fisher informing him of the award, as well as expressing to him our appreciation of the Exhibit.'

'Yours very truly,

'(Sgd.) J. O. ORR,

'*Manager and Secretary.*'

OTHER MATTERS.

St. Louis Exhibition.

The display of the economic minerals of the Dominion at the International Exhibition to be held at St. Louis, U.S., in 1904, in commemoration of the purchase of Louisiana by the United States, is being attended to by the Department of Agriculture. Mr. R. L. Broadbent of the Geological Survey has been attached to that department in order to collect, install and look after this part of the Canadian exhibit.

Educational collections.

The distribution of minerals and rocks to educational institutions in all parts of the Dominion has been continued this year, and the collections enumerated in Dr. Hoffmann's report, herewith, have been placed where they will be of great service to students. A considerable stock of material for these collections was obtained from the best localities known by Mr. C. W. Willimott during the summer. The details of this work are given in Dr. Hoffmann's report in the present volume.

Committee on geological nomenclature.

The International Committee on geological nomenclature, composed of two members of this Survey and two from the Geological Survey of the United States, and which was referred to in the last Summary Report, held a meeting in St. Louis, Mo., in December, at which all the members, namely, Professor Van Hise and Dr. Hayes for the United States and Dr. Robert Bell and Dr. F. D. Adams for Canada, attended, and it was arranged to do some joint field-work the coming summer, in order, if possible, to agree upon certain facts as preliminary to other work.

Proposed permanent exhibit in New York.

As much of the capital for the development of the mineral wealth of Canada has heretofore come from the city of New York, and as it would be very desirable to encourage further interest in our mines from this quarter, it may be advisable, considering the small cost that would be incurred, to place a collection of our economic minerals on permanent exhibition in that city. Looking forward to the possibility of this, I conferred with Professor Bickmore of the American Museum of Natural History on the subject, and found that he was very favourably disposed to assist in this proposal. If the matter be followed up, it may result in the establishment of a valuable agency there at a very

trifling cost. A similar collection is already installed at the Imperial Institute in London under the care of Professor Dunstan, Director, and Mr. Harrison Watson, Canadian Agent.

UTILIZATION OF LOW-GRADE PHOSPHATE ROCK.

Low-grade phosphate rock.

Dr. Wilhelm Palmer of Stockholm, Sweden, has just patented in Canada a process for the extraction of a soluble phosphate of lime from apatite-bearing rocks of low grade, which, at ordinary prices, it would not pay to dress mechanically to such a percentage as would render them profitable to export for the manufacture of fertilizers. According to the description of this process, by means of the electrolysis of chlorate of sodium, a fresh solution of chloric or perchloric acid is obtained at the anode and of hydrate of sodium at the cathode. In a separate vessel, the apatite of the low-grade phosphatic rock, in a state of powder, is dissolved out by the chloric acid thus obtained and then precipitated by the sodium hydrate. It is claimed that the chloric acid can be recovered and used for the treatment of fresh portions of the powdered rock. If this process can be carried on at a sufficiently low cost, it may possess promising possibilities, especially when the price of phosphatic fertilizers is higher than at present.

THE INTERNATIONAL GEOLOGICAL CONGRESS.

International Geological Congress.

Early in March, 1903, a request was received from the secretary of the organization committee of the International Geological Congress, requesting an invitation from Canada to hold the tenth triennial Congress in 1906 in this country. After due consideration, the Hon. the Minister of the Interior obtained the consent of parliament for a grant of $25,000 towards meeting the expenses of holding the congress in Ottawa, and I was deputed by him, on behalf of the government and also as the representative of the Royal Society of Canada, to proceed to Vienna, where the ninth Congress was to be held, in order to personally extend to it Canada's invitation. This decision had been reached only in time to allow me to arrive in Vienna at the opening of the session on the 20th of August. About the same time that the above request had been forwarded to Canada, the secretary had sent to Mexico a similar request for an invitation from that country. It was not before my arrival at Vienna that I ascertained that the government of Mexico had immediately on receipt of the secretary's letter telegraphed the desired invitation and had at once sent an agent to Europe to canvas for its acceptance by the congress during the five months preceding the meeting, On the question of a choice being put to the congress, it

was found that there was a large majority in favour of going to Mexico for the meeting of 1906.

List of Publications on Economic Minerals by the Geological Survey of Canada.

Publications on economics.

The following is a list of the principal publications bearing on Economic Minerals and Mining Districts in Canada, issued by the Geological Survey. The list comprises the subjects which have been rather fully written up or which have been the object of special investigation by the various officers of the Department. This does not by any means represent the total amount of information of a direct commercial character contained in the Reports of the Survey. Scattered through the various reports are numerous references, often important, to mineral occurrences, ores, mines, &c. Such references of this kind as appeared in the reports published previous to 1885 are entered in the "Index to Reports, 1863-1884," while each of the volumes of the New Series of Reports since 1885 contains its own index.

Reports of chemical section.

Besides these the regular annual reports of the Chemical Section are in their nature most largely economic, and of these 12 have been published since the "Geology of Canada, 1863," was issued and some 8 reports previous to that volume. The annual reports of the Mines Section of the Survey, give not only a statistical presentment of the mineral industries of Canada, but special articles are also embodied each year, giving in condensed form descriptions of Canada's economic mineral districts and resources. Of these, 16 have been issued since 1887, when this branch was inaugurated.

In addition to the above publications, there are perhaps an equal number of the Geological reports on districts mapped in the usual course of the Survey work which include information about important groups of economic mineral deposits and on mining districts.

Of the maps issued, at least 100 cover specific mining districts.

Enumeration.

To sum up—the publications of the Survey on economic subjects are as follow :—

Special economic publications	75
Chemical Section Reports	20
Mines Section Reports	16
General Geological Reports, which include descriptions of mining districts, occurrences of economic minerals, &c., about	126

Bulletins prepared, in course of preparation and published to January, 1904	18
Maps covering mining districts, about	100
Maps, geological, but of economic interest, about	250
	605

In all about 605 publications of direct economic interest may therefore be obtained from the Geological Survey.

CANADA. (GENERAL.)

Canada in general.

No. in the List of Publications.

Apatite.

126 On Canadian Apatite.—Hoffmann. Rep. of Prog., 1877–8. (14 pp.)

Reprint. Report on the Canadian phosphates considered with reference to their application to agriculture.—Brome, G., 1870. (23 pp.)

Iron ores.

96 Notes on the iron ores of Canada and their development.—Harrington. Report of Prog., 1873–4. (70 pp.)

Marl.

Reprint. Marl deposits in Ontario, Quebec, New Brunswick and Nova Scotia.—Ells, 1902. (10 pp.)

Petroleum.

63 On the Geology of Petroleum.—Hunt. Rep. of Prog., 1863–6. (30 pp.)

Salt.

63 Geology of salt deposits.—Hunt. Rep. of Prog., 1863–6. (18 pp.)

General Reports.

50 Geology of Canada.—Economic Geology and Mining prior to 1863. (164 pp.)

167 Report of observations on some mines and minerals in Ontario, Quebec and Nova Scotia.—Willimott, Rep. of Prog., 1882–4. (28 pp.)

221 Observations on Mining Laws and Mining in Canada with suggestions for the better development of the mineral resources of the Dominion.—Coste. Vol. 1. (N.S.) Part K. (15 pp.)

Mineral statistics and mines.

* Mineral Statistics and Mines.—Annual Reports of the Section of Mines of the Geological Survey of Canada, 1886 to 1902.

List of Publications Number.			List of Publications Number.		
245	....Report for	1886	602	....Report for	1895
272	"	1887	625	"	1896
300	"	1888	662	"	1897
301	"	1889	698	"	1898
334	"	1890	718	"	1899
335	"	1891	744	"	1900
360	"	1892	800	"	1901
572	"	1893–4	836	"	1902

Descriptive catalogues.

Descriptive catalogues of economic minerals displayed at International exhibitions. These contain descriptions of economic minerals, deposits, quantities, utilization, values, &c.

394 Paris Exhibition, 1855.

398 London International Exhibition, 1862.

402 Paris Mineral Exhibition, 1867.

405 Philadelphia International Exhibition, 1876.

406 Paris International Exhibition, 1878.

409 Colonial and Indian Exhibition, London, 1886.

413 Chicago World's Columbian Exhibition, 1893.

693 Paris Exhibition, 1900.

Handbooks, descriptive of Canada's Mineral resources; prepared for the followingexhibitions, Paris, 1900; Glasgow, 1901; Cork, 1902; Wolverhampton, 1902.

Records of mines.

86 Records of Mines and Mineral Statistics. Compilation by Charles Robb, of results of statistics, &c., collected by R. Bell and E. Hartley, Rep. of Progress, 1873.

* The Annual Reports of the Section of Mines present yearly statistics (figures of production, imports and exports) and the state of the Canadian Mining Industry, as well as a large amountof technological matter relating to mining, descriptions of mines, development of mineral deposits, &c. From time to time, special articles on various mineral subjects of economic interest have been written by the officers of the Section and other members of the Geological Survey staff, as the result of personal investigation and of compilation of data from reliable sources. A list of the subjects thus written up more or less fully in the Reports of the Mines Section will be found on page 14.

Trans. Roy. Soc. Canada.—The Huronian System of Canada. Vol. V., Sect. 4, 1888.—R. Bell.

Canadian Naturalist and Geologist.—Roofing Slate as a Source of Wealth in Canada. Vol. III, 1863.—R. Bell.

Proceedings Canadian Inst.—The Mode of Occurrence of Apatite in Canada, Ser. III, Vol. III, 1884–5.—R. Bell.

Fourteen annual reviews of the progress of mining in Canada, from 1863 to 1877, published in Monetary Times, Montreal; Engineering and Mining Journal, New York; Mining Journal, London; reports of Trade and Commerce of Montreal.—R. Bell. Mining reviews.

Sketch of the Geology of the Provinces of Ontario and Quebec. Walling's Atlas and Gazetteer of Canada, 1875.—R. Bell.

NOVA SCOTIA. Nova Scotia.

Coal.

69 Reports on parts of Pictou coal-field, with appendix on coals and iron ores.—Hartley and Logan, 1870. (186 pp.)

89 On the coal mines of Eastern or Sidney coal-field.—Robb, C. Rep. of Prog., 1872–3. (52 pp.)

101 Report of explorations and surveys in Cape Breton; with especial reference to coal areas.—Robb, C. Rep. of Prog., 1874–5. (100 pp.)

685 Descriptive note on the Sidney coal-field.—Fletcher, 1900. (16 pp.)

94 On the exploration and survey of the Springhill coal-field, Cumberland County.—Barlow, S. Rep. of Prog., 1873–4. (13 pp.)

94 On a portion of the coal-field of Cumberland County.—McOuat. Rep. of Prog., 1873–4. (6 pp.)

817 Coal of Cumberland County, with map of Springhill colliery.—H. Fletcher. Summary Rep., Geol. Survey, 1902.

Gold.

407 Report on the gold regions of Nova Scotia.—Sterry Hunt. 1868. (48 pp.)

7 Reports on the Nova Scotia gold fields. Summary Reports 1888–1903. Numbers on list of publications: 259, 293 320, 323, 353, 355, 553, 583, 614, 644, 674, 691, 717, 762, 807.

Iron Ores.

89 On the Acadia iron ore deposits of Londonderry, Colchester County.—Selwyn. Rep. of Prog., 1872–3. (12 pp.)

Reports on economics.

69 Iron ores and coals of Pictou coal field. Appendix to the the report on part of Pictou coal field.—Hartley and Logan, 1870.

General.

243 Economic minerals of the counties of Guysboro', Antigonish, Pictou, Colchester and Halifax.—Fletcher and Faribault. Vol. II. (N.S.) Part P. (16 pp.)

331 Economic minerals in counties of Pictou and Colchester.—Fletcher. Vol. V. (N.S.) Part P. (23 pp.)

628 Economic minerals in south-west Nova Scotia.—Bailey. Vol. IX., Part M. (20 pp.)

816 Geology of Prince Edward Island, with reference to proposed boring for coal.—Ells. Summary Geol. Survey, 1902.

New Brunswick.

New Brunswick.

Albertite.

114 Composition of albertite as compared with coal and asphalt, and report on Albert and Westmoreland Counties.—Bailey and Ells. Rep. of Prog., 1876–7. (14 pp.)

816 The Albert shales deposits.—Ells. Summary Report, 1902. (7 pp.)

Coal.

803 The coal prospects of New Brunswick.—Poole, H. S. Vol. XIII., Part MM.

Iron Ores.

101 On the iron ore deposits of Carleton County.—Ells. Rep. of Prog., 1874–5. (7 pp.)

General.

661 The mineral resources of New Brunswick.—Bailey. Vol. X, Part M. (128 pp.)

QUEBEC AND LABRADOR.

Quebec and Labrador.

Apatite.

167 Report on the Apatite deposits of Ottawa County.—Torrance, J. F.—Rep. of Prog., 1882–4. (32 pp.)

126 On Canadian Apatite.—Hoffmann. Rep. of Prog., 1877–8. (14 pp.)

94 Notes on Apatite in Templeton and Portland Tps. and on Graphite in Buckinghan Tp.—Vennor. Rep. of Prog., 1873–4. (36 pp.)

114 Notes on Apatite, iron ore and plumbago deposits of Ottawa County.—Vennor. Rep. of Prog., 1876–7. (31 pp.)

763 On occurrences of apatite, mica and graphite north of Ottawa.—Osann. Vol. XII. Part O. (84 pp.)

Copper.

50 Copper-bearing rocks of the Eastern Townships.—Geol. of Can., 1863. Sir W. E. Logan.

63 List of copper localities in Eastern Canada. Rep. of Prog., 1863–6. (26 pp.)

816 Investigations on the copper-bearing rocks of the Eastern Townships.—Dresser. Summary, 1902. (14 pp.)

Graphite.

Graphite.

119 On Canadian graphite.—Hoffmann. Rep. of Prog., 1876–7. (24 pp.)

110 Examination of graphite from Buckingham Tp.—Hoffmann. Rep. of Prog., 1875–6. (14 pp.)

94 Notes on graphite of Buckingham Tp. and apatite of Templeton and Portland Tps.—Vennor. Rep. of Prog., 1873–4. (6 pp.)

114 Notes on plumbago, iron ores and apatite deposits of Ottawa County.—Vennor. Rep. of Prog., 1876–7. (31 pp.)

763 On occurrence of graphite, mica and apatite north of Ottawa. —Osann. Vol. XII. Part O. (84 pp.)

On the mode of occurrence of plumbago in Grenville.—Published in New York, 1866. R. Bell.

Gold.

Gold.

64 On the gold regions of Lower Canada.—Logan, Michel and Hunt. Rep. of Prog., 1863–6. (38 pp.)

8 On the gold of the Chaudière river and vicinity.—Logan. Rep. of Prog., 1850–1. (6 pp.)

399 Notes on the gold of Eastern Canada.—Reprints of various portions of reports of the Geological Survey of Canada, from 1848 to 1863. (40 pp.)

460 Reports of the gold regions of Canada.—Michel and Hunt, 1866. (72 pp.)

583 Notes on alluvial gold mining in the Chaudière district.—Chalmers. Summary Rep., 1895. (12 pp.)

670 History and development of gold mining industry in the Chaudière District.—Chalmers, Vol. X, Part J. (90 pp.)

Iron Ores.

591 Iron ores of the district north of Montreal, with appendix on the smelting of titaniferous iron ores.—Adams, Vol. VIII, Part J. (44 pp.)

114 Notes on iron ores, apatite and plumbago deposits of Ottawa County.—Vennor. Rep. of Prog., 1876–7. (31 pp.)

Petroleum.

Petroleum.

400 Petroleum.—Its geological relations considered with special reference to its occurrence in Gaspé.—Hunt, T. S., 1865. (19 pp.)

816 Report of operations and description of Gaspé oil field.—Ells. Summary Rep., 1902. (23 pp.)

400 Geological and topographical map of a portion of Gaspé Peninsula, from surveys by Dr. Bell, accompanying report on occurrence of petroleum in that region. Pamphlet published by the Geological Survey.

General. General.

Report on alleged discovery of coal at Baie St. Paul. Rep. of Prog., 1849.—Logan. (8 pp.)

297 Report on the mineral resources of the Province of Quebec. —Ells. Vol. IV., Part K. (159 pp.)

739 Economic minerals of the Ottawa River map sheet.—Ells. Vol. XII, Part J. (44 pp.)

154 Notes on some of the mines in the Province of Quebec. In the Eastern Townships and in Ottawa County.—Willimott. Rep. of Prog., 1880–2–4. (25 pp.)

268 Economic minerals in the counties of Megantic, Beauce, Dorchester, Lévis, Bellechasse and Montmagny.—Ells. Vol. III, Part K. (13 pp.)

591 Economic minerals of a portion of the Laurentian area north of Montreal.—Adams. Vol. VIII, Part J. (44 pp.)

584 Economic minerals of Labrador Peninsula along the East Main, Koksoak, Hamilton and other rivers.—Low. Vol. VIII, Part L. (7 pp.)

819 Geology of the Nastapoka islands, Hudson Bay.—A. P. Low. Vol. XIII. Part DD.

125 Exploration of the east coast of Hudson Bay, with map of the East-main coast. Rep. of Prog., 1877–8.—R. Bell.

Trans. Royal Soc. Canada.—The geology and economic minerals of Hudson Bay and northern Canada. Vol. II, 1884. R. Bell.

Trans. American Institute of Mining Engs.—The Mineral Resources of the Hudson Bay Territories.—Feb. 1886. R. Bell.

Report Dept. Marine and Fisheries.—Report on Labrador Coast and Hudson Strait. 'Neptune' Expedition, 1884. R. Bell.

Report Dept. Marine and Fisheries.—Report on Geology of Hudson Bay and Strait. 'Alert' Expedition, 1885.—R. Bell.

Report Dept. Marine and Fisheries.—Report on the third Hudson Bay expedition, 1886. R. Bell.

ONTARIO. Ontario.

Apatite.

83 On phosphate of lime and mica in Eastern Ontario.—Broome, G. Rep. of Prog., 1870–71. (5 pp.)

Copper.

See also under *Nickel.*

63 On the copper-bearing rocks of Lake Superior.—Macfarlane, T. Rep. of Prog., 1863–66. (45 pp.)

4 On the geology and economic minerals of Lake Superior.—Logan. Rep. of Prog., 1846–47. (46 pp.)

391 Remarks on the mining region of Lake Superior and report on mining locations on Canadian shore of the lake.—Logan, 1847. (31 pp.)

392 Report on the north shore of Lake Huron, with appendix on the contents of lodes.—Logan, 1849. (51 pp.)

816 Note on geology and mineral deposits of Bruce Mines district.—Ingall. Summary Rep., 1902. (10 pp.)

Nickel.

Nickel.

Bulletin Geol. Soc. America.—The Nickel and Copper deposits of the Sudbury district, Vol. II. Feb., 1891. R. Bell.

326 Report on the Sudbury Mining district.—R. Bell. Vol. IV., Part F. (95 pp.)

Reprint On the Nickel and Copper deposits of the Sudbury district. —Barlow, 1891. (18 pp.)

816 The Sudbury Mining district.—A. E. Barlow. Summary Rep., 1902. (15 pp.)

761 Sudbury Mining district.—A. E. Barlow. Summary Rep. Geol. Surv., 1901.

816 Sudbury Mining district.—A. E. Barlow. Summary Rep. 1902. (15 pp.)

Corundum.

Corundum.

644 Note on the Corundum belt of Hastings district.—A. E. Barlow. Summary, 1897. (18 pp.)

Gold.

403 Report on the Gold region of the county of Hastings.—Hunt and Michel, 1867. (11 pp.)

167 Report on the Gold region of the Lake of the Woods.—Coste. Rep. of Prog., 1882–84, Part K. (21 pp.)

Iron Ores.

723 Report on the iron ores of the Kingston and Pembrooke Ry. district.—Ingall. Vol. XII., Part I. (91 pp.)

Natural Gas.

332 Report on Natural Gas and Petroleum in the province of Ontario prior to 1891.—Brumell. Vol. V., Part Q. (94 pp.)

Petroleum. Petroleum.

332 Report on natural gas and petroleum in Ontario prior to 1891.—Brumell. Vol. V. Part Q. (94 pp.)

Trans. Roy. Soc., Canada.—The petroleum field of Ontario.—Vol. V., Sect. 4, 1887. R. Bell.

63 Geology of Grand Manitoulin island, as to anticlinals and petroleum.—Report Geol. Survey, 1863–6. R. Bell.

Salt.

71 On the Goderich salt region.—Hunt, T. S. Rep. of Prog., 1866–9. (36 pp.)

117 The Goderich salt region and Attrill's exploration with the diamond drill.—Hunt, T. S. Rep. of Prog., 1876–7. (23 pp.)

101 Observations on the history and statistics of the trade and manufacture of Canadian salt.—Smith, J. L. Rep. of Prog., 1874–5. (33 pp.)

63 On the geology of salt.—Hunt, T. S. Rep. of Prog., 1863–6. (15 pp.)

Silver.

266 Report on mines and mining on Lake Superior.—Ingall. Vol. III, Part H. (131 pp.)

General. General.

101 Notes on some of the economic minerals of eastern Ontario.—Vennor. Rep. of Prog., 1874–5. (50 pp.)

215 Economic minerals of the lake of the Woods region.—Lawson. Vol. 1., Part CC. (11 pp.)

672 Economic minerals of the Temiscaming district.—A. E. Barlow. Vol. X, Part I. (21 pp.)

678 {Economic minerals of area of Seine river and Lake Shebandowan sheet.—McInnes. Vol. X, Part. H. (4 pp.)

155 Report of the geology on the Lake of the Woods and adjacent country.—Rep. of Prog., 1880–1–2. R. Bell.

Canadian Naturalist and Geologist.—The mineral region of Lake Superior. Ser. II, Vol. 7, 1875. R. Bell.

Geology of Ontario with special reference to economic minerals. (52 pp.) R. Bell. Report of Royal Commission on mineral resources of Ontario.—1890.

Glossary of Terms used in Geology and Mining. R. Bell. (18 pp.)

The Laurentian and Huronian systems north of Lake Huron. (36 pp.) Report Bureau of Mines, 1891. R. Bell.

Manitoba and Northwest Territories.

MANITOBA AND NORTHWEST TERRITORIES.

Coal.

*408 Note on the geology of the Bow and Belly rivers with especial reference to the coal deposits.—Dawson, G. M., 1882. (24 pp.)

168 Analyses of coals and lignites of the Northwest Territories. —Hoffmann. Rep. of Prog., 1882–4, Part M. (44 pp.)

Reprint. Report on the Tertiary lignite formation in the vicinity of the 49th parallel. Dawson, 1874. (31 pp.)

816 Note on the Blairmore—Frank coal-field.—Leach. Summary Rep., 1902. (11 pp.)

717 Note on the lignite areas and copper deposits of Yukon Territory.—McConnell. Summary Rep., 1900. (7 pp.)

147 On the lignite tertiary formation from the Souris river to the 108th Meridian.—Dawson, G. M. Rep. of Prog., 1879–80, Part A. Appendix I.

Copper.

Copper.

717 Note on copper deposits and lignite areas of Yukon Territory.—McConnell. Summary Rep. Geol. Survey, 1900. (7 pp.)

* Also Rep. of Prog., 1880-1-2, Part B.

Gold.

687 Preliminary report on the Klondike gold field.—McConnell. 1900. (44 pp.)

761 The Yukon district—McConnell. Summary Report for 1901.

The geology of the Klondike Gold district.—McConnell—(in preparation.)

General.

General

325 Economic minerals of Northwestern Manitoba and adjacent parts of Assiniboia and Saskatchewan.—Tyrrell. Vol. V, Part E. (12 pp.)

237 Economic minerals of Northern Alberta and adjacent parts of Assiniboia and Saskatchewan.—Tyrrell. Vol. II, Part E. (7 pp.)

167 On part of the basin of Athabaska river. R. Bell—Rep. of Prog., 1882-3-4. Part CC.

324 Economic minerals of portions of district of Athabaska between Peace river and Athabaska river.—McConnell. Vol. V, Part D. (5 pp.)

629 Report on an exploration in the Yukon district, N. W. T., and adjacent northern portions of British Columbia, 1887.—G. M. Dawson.

816 Economic minerals of region west of Fort Smith, Slave river.—Camsell. Summary Rep., Geol. Survey, 1902.

816 Economic minerals of Eastern Assiniboia and Southern Manitoba.—Dowling. Summary Rep., 1902. (21 pp.)

Proceedings Canadian Inst. On the occurrence of petroleum in the Northwest Territories.—Ser. III, Vol. I, 1879-83. R. Bell.

BRITISH COLUMBIA.

British Columbia.

Coal.

84 On the coal-fields of the east coast of Vancouver island.—Richardson. Rep. of Prog., 1871-2. (18 pp.)

89 On the coal-fields of Vancouver and Queen Charlotte islands.—Richardson. Rep. of Prog., 1872-3. (32 pp.)

114 Report on the coal-fields of Nanaimo, Comox, Cowitchin, Burrard Inlet, and Sooke, B.C. Richardson. Rep. of Prog., 1876-7. (32 pp.)

717 Preliminary Note on Crows Nest Pass coal-field.—McEvoy. Summary Rep., 1900. (10 pp.)

Copper.

816 Preliminary report on the Boundary Mining district.—Brock. Summary Rep. Geol. Survey, 1902. (45 pp.)

Gold.

Gold.

816 Preliminary report on the Boundary Mining district.—Brock. Summary Rep. Geol. Survey, 1902. (45 pp.)

263 Report on the Geology of the Mining district of Cariboo.—Bowman. Vol. III. Part C. (49 pp.)

743 Report on Atlin Mining district.—Gwillim. Vol. XII. Part B. (48 pp.)

General.

General.

271 The Mineral Wealth of British Columbia, with a list of localities of minerals of economic value.—Dawson, G. M. Vol. III. Part R. (163 pp.)

115 General note on the mines and minerals of economic value of British Columbia, with a list of localities.—Rep. of Prog., 1876-7. (47 pp.)

294 Economic minerals of a portion of the West Kootenay district.—Dawson. Vol. IV. Part B. (23 pp.)

573 Economic minerals in area covered by Kamloops map-sheet.—Dawson. Vol. VII. Part E. (38 pp.)

Reprint. Report on climate, agricultural value, general geological features and minerals of economic nature of part of northern portion of British Columbia, and the Peace River country.—Dawson, 1880. (25 pp.)

BAFFINLAND.

Baffinland.

Report on the south coast of Baffinland containing notes on mica, graphite, apatite and limestones. Annual Report for 1897, with a map.—Dr. R. Bell.

ANNUAL REPORTS OF THE MINES SECTION.

Analysis of Contents (other than the Statistics).

Precious Stones—

Pyrites—

Salt.

Salt—

Soapstone—

Zinc—

OFFICERS' REPORTS.

Klondike District, Yukon Territory.

Mr. R. G. McConnell.

Klondike district.

The principal work of the season consisted of a somewhat detailed examination of the geology and mining resources of the Klondike region; but before proceeding there, a short trip was made to Frank, Alberta, with Mr. Brock, for the purpose of examining into the causes of the disastrous land-slide which occurred at that place in April. A short report on the slide, with maps and illustrations, was prepared before leaving for the field.

Field work.

I left Ottawa for Dawson on June 12, and arrived there on June the 24th. The three months of open season remaining was spent altogether in the Klondike gold fields, with the exception of a few days occupied in a trip to the coal-field recently opened up on Coal creek, and in a hurried examination of the Ogilvie range, at the head of Rock creek.

A preliminary examination of the Klondike gold fields was made by the writer in 1899, and a report of it published the following winter. It is intended to re-write this report during the coming winter and to add to it the additional information acquired since. It is unnecessary

therefore in this summary to give any detailed description of the district or do more than refer to some of the changed conditions.

The gold production of the Yukon Territory since the discovery of the Klondike gold fields in 1896, is valued by the Mines Section of the Department, at nearly $96,000,000. The production by years is as follows :— Production of Klondike gold field.

1896	$ 300,000
1897	2,500,000
1898	10,000,000
1899	16,000,000
1900	22,275,000
1901	18,000,000
1902	14,500,000
1903	12,250,000
	$ 95,825,000

The whole of this great amount, with the exception of about $1,000,000, credited to the smaller camps, was obtained from the various Klondike creeks and benches, and principally from Bonanza, Eldorado, Hunker and Dominion creeks, and the Bonanza benches. The decreasing production since 1900, in spite of the increasing use of machinery, is largely due to the gradual exhaustion of the phenomenally rich spots on Eldorado and Bonanza creeks, and on some of the Bonanza benches, and does not mark a corresponding decline in the mining industry of the region. The number of creek claims worked, and the amount of gravel handled, have increased rather than diminished in recent years, but the average grade of the gravel mined is much lower. Very few claims, if any, on the more important creeks are being abandoned, even when completely worked over, as there is a general expectation that most of them will pay to be re-worked, especially if a water-supply system is established, and some of them are being re-worked under present conditions. Worked-out claims on the richer portions of Eldorado creek are worth from $10,000 to $15,000 each. Condition of camp.

The high-level gravels, so far as placer mining is concerned, show greater signs of exhaustion than the creek gravels. Work has almost stopped on some of the principal Bonanza hills and the number of men employed is steadily decreasing. These gravels are much deeper than the creek gravels, usually ranging in this respect from 50 feet to 150 feet, and only the lower three to five feet over part of the area covered, is rich enough to work by the ordinary methods. They are High-level gravels.

well situated for hydraulicking, but the scarcity of local water prevents the general adoption of this method.

Old creeks restaked.

No new creeks of importance have been discovered since 1899, although in some cases creeks and portions of creeks, which had been staked and partially or wholly abandoned, on account of the low grade of the gravels, are now being worked. This has occurred in the case of All Gold creek, a tributary of Flat creek. The valley of this creek was staked in the early days of the camp from head to mouth; a few holes were sunk to bed rock, but as no particularly rich spots were discovered, the claims were all, or nearly all, abandoned. They have been re-staked during the last two seasons and pay gravel has been found at a number of points. The longest pay-stretch, so far discovered, occnrs near the mouth of the creek, where several adjoining claims are being worked. The pay is light, none of the claims yielding much more than good wages and some scarcely that. All Gold creek heads with Dominion and Hunker creeks, but flows in the opposite direction towards the Flat creek depression, and it is the only creek draining the eastern and northeastern slopes of the Klondike hills on which gold in paying quantities has so far been discovered. The general character of the valley and of the gravels conforms to the general type. The White channel gravels occur in considerable volûme on the left limit, along the lower portion of the valley, and are overlaid near the mouth of the creek, as is the case on Bonanza and Hunker creeks, by rounded river gravels. They rest on a bench of varying width, cut into the side of the valley at an elevation of from 150 to 250 feet above the present creek-bottom, the elevation increasing, as usual, towards the mouth of the valley. The White channel gravels of All Gold creek have not, so far, yielded gold in paying quantities. Fair prospects are reported from a couple of places, but on account of the scarcity of water for sluicing purposes, practically no work has been done.

All Gold creek.

Lower Dominion

The lower part of Dominion creek, like All Gold creek, was largely abandoned after the first rush, but is now, particularly between the mouths of Gold Run and Sulphur creeks, one of the busiest localities in the Klondike. The valley of Dominion creek from Jansen creek down to the mouth, is very wide, the flats along this portion averaging from a third to half a mile in width. The pay streak in these wide flats was difficult to find, and it required the patient and systematic prospecting of several seasons to define it along the valley. The gravels are not high grade in the Eldorado meaning of the word, but most of the claims yield fair returns when carefully worked. The depth to bed-rock averages about 35 feet.

Lower Dominion gravels.

The gravels on the lower part of Dominion, Sulphur and Gold Run creeks differ from the ordinary creek gravels of the district. They consist of a deposit of white silicious gravels in the lower part and flat yellow gravels above. The latter represents the wash of the stream at present, but the former probably belongs to the period of the high-level White channel gravels. At first sight it appears peculiar to find these gravels on Bonanza, Hunker and other creeks, occupying high benches, while on Dominion and Sulphur creeks they underlie the present valley flats, but the apparent anomaly admits of an easy explanation. Their elevated position on Bonanza and Hunker creeks has been explained in former reports as being due to an elevation of the country, which gave the streams increased grades and enabled them to cut deep, steep-sided secondary valleys in the floors of their old channels. Both Bonanza and Hunker creeks discharge almost directly into the Yukon, the master stream of the district, and they were affected immediately by the deepening of the Yukon valley. Dominion creek, on the other hand, empties into Indian river, many miles above the junction of the latter with the Yukon. Indian river is itself a comparatively small stream, and the increased cutting power which it acquired in common with the other streams after the elevation of the country, has been expended in the lower portion of the valley and has not, so far, materially affected the upper portion. A secondary valley, in places narrowed to a canyon, is traceable from the mouth of the Indian river upstream to a point above Quartz creek, where it merges with the older valley. The wide flats which form the bottom of the valley of the main stream, and of the large tributaries like Dominion creek, above this point, correspond therefore, in a general way, to the old valleys of Bonanza and Hunker creeks, now represented by high benches, and not to the present valley bottoms. The white gravels on Dominion creek are comparatively thin, seldom exceeding 15 feet in thickness and at places are absent altogether.

Other creeks.

The pay-streak on Lower Dominion commences at Gold Run creek and is apparently a continuation of the pay-streak of that creek, as no paying claims have so far been discovered above the mouth of Gold Run for several miles. The pay-streak has been traced down the valley almost to the mouth of Australia creek.

Cost of mining.

The great reduction in the cost of mining, which has given value to these comparatively low grade gravels, is due not to any radical change in the methods of mining, so far as the laying out of the work is concerned, but to the great cheapening of freight rates up the creeks since the construction of the government roads and to the general introduction of machinery. The ordinary equipment of a mine on Dominion

creek costs from $5,000 to $8,000 on the ground, and consists of a 35 to 50 H.P. boiler for furnishing power, a hoist and self-dumping bucket, worked by an 8 to 10 H.P. engine, a centrifugal pump, with a six-inch discharge for elevating water for sluicing, driven by an engine usually of about 15 H.P. and a small Worthington pump with a three-inch discharge and a one-inch nozzle for thawing, or a set of points when the thawing is done by steam. The operating expenses of an ordinary plant, with one shift and night thawing, amounts to about $100 per day, and from 50 to 60 cubic yards of material are mined and sluiced daily. The cost of handling a cubic yard of gravel has been reduced nearly one-half since 1899.

Two methods. The two methods of mining commonly employed in the Klondike, viz., by open cut, or by hoisting and drifting, are described in the Summary Report for 1899. These methods are still generally employed, the principal change being in the substitution of machinery for hand labour. In a few cases, however, attempts have been made, more or less successfully, to introduce cheaper methods. A dredge, originally intended for work on the Lewis river, has been operating on Bonanza creek for the last three seasons. The work done has shown that when the gravels are completely thawed out, they can be mined very cheaply by dredging, but when frost is encountered, thawing, as in the other methods must be resorted to. In dredging also the bed-rock is not seen, and there is always some uncertainty in regard to the completeness of the recovery of the gold. Where the bed-rock is hard and blocky, the gold often sinks down along the jointage and bedding planes to a depth of 4 or 5 feet, and some of it must almost necessarily be left behind. In soft bed-rock, on the other hand, the recovery of the gold is probably nearly complete.

Dredging.

Steam shovels. Steam shovels are employed on several claims in the district, and where the conditions are suitable, they handle the gravels and certain kinds of bed-rock cheaply and effectively. The overlying muck requires to be sluiced off in the ordinary way, and the gravels must be thawed out before good work can be done.

Cheap mining. Another attempt at cheap mining in the creeks introduces the hydraulicking principle, but it is still only in the experimental stage. On Gold Run creek two claims have been equipped with long China pumps and bucket elevators. The pumps and elevators, each about 70 feet in height, rest in a sump, excavated 12 to 14 feet in bed-rock. The gravels are washed into the sump by a stream of water under small pressure, and are carried up by the bucket elevator and dumped into the sluice boxes. The China pump elevates the water used in hydraulicking and it serves again to wash the gravels. It is proposed

to mine a number of the claims on Gold Run creek by this method if the two experimental plants prove successful.

Hydraulicking.

The high level, White channel gravels along Bonanza and Hunker creeks, are still largely worked by the expensive sinking and drifting method, and until an adequate water-supply system is established, this is the only possible method on the majority of the hills. A number of attemps to hydraulic these gravels have been made, both with gravity water and water pumped up from the creeks. The pumping method has been generally unsuccessful, and can only pay when the gravels are extremely rich, owing to the high price of fuel. Where cheap gravity water is obtainable, however, the results have been very good. The Anglo-Klondike Company, under the management of Mr. Coffee, has been operating successfully for the past two seasons two small hydraulic plants, one on Fox gulch and the other above Boulder creek. The water is flumed and siphoned from a point on Boulder creek about three miles above its mouth. A supply of about 200 inches is available for a few weeks in spring and autumn, and is delivered under a head of nearly 200 feet. In Mr. Coffee's report to his company for 1902, it is stated that in a run of 22 days, 29,000 cubic yards were sluiced and that the actual hydraulicking cost was under 15 cents per cubic yard. The total operating expenses, including cost of plant and cleaning bed-rock, amounted to 35 cents per cubic yard, or $1.96 per square yard of bed-rock. In the same report it is stated that the average cost of mining and sluicing by the ordinary drifting method amounted to $5.85 per square yard of bed-rock, or nearly three times as much.

The demonstration of the feasibility of hydraulicking successfully the frozen hill gravel is important, but under present circumstances can only be taken advantage of to a very limited extent, as the available local supply of gravity water is small and intermittent and is only obtainable at a few points.

Volume of White channel gravels.

The White channel gravels have a total volume on Bonanza creek and its tributaries of approximately 250,000,000 cubic yards, and on Hunker creek and its tributaries of 200,000,000 cubic yards. They are everywhere more or less auriferous, and sufficient work has already been done to prove that a large proportion, at least, of the whole deposit would pay to hydraulic if water could be obtained at reasonable rates. The present price of water delivered on the hills is $7 per sluice-head per hour on Lovett gulch, and $8 to $9 further up the valley, and even at these rates some work is possible. These gravels are very favourably situated for hydraulicking, as they rest on comparatively narrow benches, cut into the sides of the valley, at elevations of from 150 to 300 feet above the present valley bottom.

Quartz mining.

Quartz mining in the district has so far made little progress, although a great many claims have been staked and some development work has been done. Quartz veins occur everywhere but are usually small and non-persistent, and the values are very irregular. The large veins from 6 to 10 feet in width which are occasionally found are usually lenticular in shape and soon narrow-in, along the strike. The veins often carry more or less feldspar, and in some respects resemble the pegmatites.

Violet group.

Some work was done during the past season on a claim in the Violet group, situated on the summit of the ridge separating Eldorado creek from Ophir creek, a tributary of Indian river. The workings consist of a short open cut and a couple of shafts. The open cut follows a quartz vein 5 to 6 feet in width, broken by a number of small faults. The vein strikes with the enclosing schists in a south-easterly direction, but dips across them. A shaft has been sunk a short distance north of the vein to intercept it in depth, and it is intended to continue it down to a depth of 150 feet. The quartz contains considerable iron pyrites and near the surface weathers to a rusty colour. Some gelena is also present. The gold values are variable, but are stated to average from $10 to $11 per ton.

Lepine creek.

A visit was made during the season to Lepine creek, north of the Klondike, where a large number of claims have been staked on a band of sericite schist, the ordinary country rock of the district. Only one claim was worked during the past season. This claim is situated south of the deep valley of Ruiter creek, a tributary of Lepine creek. The schists here are traversed by a wide dyke, probably an acid andesite and both schists and dyke-rock are completely decomposed to a depth of at least 15 feet. This decomposed material constitutes the ore. A tramway, half a mile in length, has been built, and the ore is trammed down to Ruiter creek and treated in a small cyanide plant. The result of the season's operations is not known. A number of specimens were collected, which are being assayed.*

Ore in Ogilvie range.

Considerable prospecting was done during the season in the Ogilvie range, north-east of Dawson, and a number of claims were located on Rock creek, a tributary of the Klondike, and on Spotted Fawn creek, a tributary of Twelve-mile river, but only a few of these were examined. The rocks on the south-westerly slope of this range consist of cherts, dark slates, shales and quartzites, with occasional bands of tuffs and green schists, a succession very similar to that on the Upper MacMillan river. Areas of igneous rocks also occur, principally syenites and diorites, and on the North Fork of Spotted Fawn creek exposures of an interesting leucite rock were found.

* The results will appear as an appendix to this volume.

A marked feature of the range is the peculiar forms of the mountains in an area of syenite porphyry, which extends from Spotted Fawn creek northward across Twelve-mile river. This rock is strongly jointed vertically, and weathers into ruinous, wedge-shaped ridges, surmounted by lines of sharp pinnacles and lofty tower-shaped peaks. The pillared character of the region is so remarkable that the prospectors have given it the name of the tombstone country. Sculpture of mountains.

A number of claims have been staked in this syenite area, principally in small, irregularly shaped inclusions of altered slate. No veins were seen. The inclusions contain varying quantities of pyrite and weather to a rusty colour on the surface. They are reported to carry gold. A small vein, a few inches in width, carrying galena and pyrite, occurs on the North Fork of Spotted Fawn creek, in a porphyry dyke cutting slates and quartzites. The vein is too small to be of value. None of the prospects examined appeared promising, but they show that the region is metalliferous to some extent and may therefore contain deposits of value.

Various efforts have been made since the Klondike gold fields were discovered to utilize the lignite seams in the vicinity. A long, narrow area of lignite-bearing rocks, probably of Tertiary age, occurs along the base of the Ogilvie range, and has been traced from the Klondike river, in a north-westerly direction, to a point beyond Cliff creek, a distance of over 60 miles. The streams draining this portion of the Ogilvie range cross the lignite area on their way to the Yukon, and on most of them outcrops of lignite coal are found. Some mining has been done on Rock creek and on Cliff creek, a small stream entering the Yukon from the east a few miles below Forty-mile river, but work is now stopped at both places. Lignite.

During the past season considerable work has been done at Coal creek by the Coal Creek Coal Mining Company. The seam worked occurs on the South Fork of Coal creek at an elevation of 960 feet above the Yukon, and the workings are connected with the Yukon by a narrow-gauge railway, eleven miles and three-quarters in length. Lignite mining on Coal creek.

The seam worked, varies in thickness from 4 to 11 feet, and is overlaid by 3 inches of clay, followed by 12 feet of moderately hard sandstone. The floor consists of 6 feet of clay, resting on 16 feet of sandstone, below which is a band of black shale. The seam dips to the south-east at an angle of 45 degrees for a distance of 210 feet from the surface, and then bends round and dips to the south-west. The principal working consists of an incline 490 feet in length. The lignite is hauled to the Yukon over a narrow-gauge railway just completed,

and taken up the river to Dawson, a distance of about 50 miles on barges. Bunkers of 500 tons capacity are in course of construction at the mine and at the river.

The coal from this seam is of good quality, and is very similar to the Cliff creek coal, an analysis of which is published in the 1901 Summary Report. It is pure for a lignite, and has been used with satisfactory results, both for steam and heating purposes. It is sold at Dawson at $16 per ton. The price of spruce wood—the usual fuel —is generally $7 to $8 per cord at Dawson, and $8 to $15 on the creeks.

Lignite on Ruby creek.

A second lignite area occurs south of the Klondike on Indian river. A small seam outcropping on Ruby creek, a tributary of Indian river, was worked to some extent during the winter of 1902, but has since been abandoned. At the time of my visit the tunnel had fallen in, and nothing could be learned in regard to either the character or size of the seam.

THE LARDEAU DISTRICT, B.C.

Mr. R. W. Brock.

INTRODUCTION.

Lardeau district, B.C.

The month of May and the first half of June were occupied in examining the Frank landslide, writing a report thereon, and laying down the geological lines on the Boundary creek topographical sheet, which had just been completed, so that it was not until June 18 hat I set out for the ordinary field-work. I was accompanied by Mr. W. H. Boyd, of this office, who again took charge of the topographical branch of the work. Our instructions were to commence the explorations of the district lying north of that embraced in the West Kootenay map-sheet, recently issued by this survey. The area covered by this new map-sheet, which may be referred to as the Lardeau sheet, is that lying between Schroeder creek, the head of Slocan lake, and the mouth of Mosquito creek, on the south; Albert canyon on the north; the divide between Kootenay lake and Duncan river and the Upper Columbia waters on the east, and the divide between Columbia and Okanogan waters on the west. Our instructions were to confine the work as far as practicable to the southern half of the sheet. Since the triangulation of the West Kootenay sheet was carried north from a short base near the southern portion of that district, it would not bear further extension northwards, so it was deemed advisable to commence the survey of the new sheet at Revelstoke on the main line

of the C.P.R., thus tying on with surveys of the railway belt made by the Dominion Lands Branch.

Revelstoke was accordingly selected as the basis of operations for the season. A tangent of five miles on the Arrowhead branch of the C.P.R. near Revelstoke which had been measured by the Dominion Lands Branch, was used as a base, and from this the triangulation of the mountains was commenced. The triangulation was carried on to Arrowhead on Upper Arrow lake, and across to Fish river. A micrometer survey was made of the east shore of Upper Arrow lake to St. Leon Springs, there tying on to the survey of the Columbia from the International boundary line, which had been made during the exploration of the west Kootenay sheet. Returning, a log-survey was made of the west shore from St. Leon to Arrowhead. From the Revelstoke Arrowhead triangulation a strip of country about 20 miles wide was surveyed south-eastward to the end of Trout lake. The boundaries of this area are Boyd creek on Fish river and the Lardeau Duncan Divide, on the north-east, and the Trout and Arrow Lake Divide on the south-west. Included in this area are the North-east Arm of Upper Arrow lake, the district about Camborne, the district about Ferguson and Ten-mile, and the Trout Lake district. The new district of Poplar creek on Lardeau river, which sprang into importance on account of the gold discoveries made there this summer, was also examined. Revelstoke. Base line used.

The season was exceptionally unfavourable for field-work. The winter snow did not melt on the higher ground until late in July. This, with the broken weather, made it impossible to carry out the work on the peaks till the end of July, August was also a wet month and on the 4th of September work on the loftier ranges was stopped by fresh snow-falls which continued during the month. On Sept. 19, on account of the unfavourable weather, field-work was abandoned, and preparations were made for returning to Ottawa. During almost half of this short season the weather made effective field-work impossible.

PHYSIOGRAPHY.

The district lies in one of the most rugged and picturesque portions of the Selkirk mountains. Huge, massive mountains, culminating in lofty craggy peaks, supporting numerous glaciers and perpetual snow-fields, are seperated by steep-walled, narrow valleys. The mountains Physiography.

NOTE.—The bearings in this report, unless otherwise stated, are magnetic. The local variation of the compass may be taken as about 25 degrees east.

are in an early stage of their life history, and are therefore thoroughly Alpine in character. The altitude of the mountains gradually increases going northward and eastward from the head of Upper Arrow lake, from rather more than 8,000 feet to perhaps 11,000, north and east of the Duncan river. West of the Columbia river the country is also rugged, individual peaks reaching 9,000 feet.. Though the Columbia valley is usually taken as the dividing line between the Selkirks and Gold Ranges, it is probable that in structure and time of formation, the range just west of the upper part of Upper Arrow lake will be found to correspond to the Selkirks, its position being explained by an arrangement of the ranges *en echelon*, like those of the Rockies.

Altitudes.

Two main valleys.

There are two main longitudinal valleys in this part of the country, which have in general a north and south trend. These are the Columbia and Arrow Lake valley in the west, and the Duncan-Kootenay valley in the east. The valleys tributary to these, in the district examined, depend for their direction largely upon the local structural features of the rocks. The rocks are mostly stratified or schistose, folded in general along north-west and south-east axes, with a vertical system of master-joints at right angles to the direction of folding. Conforming to this structure, the valleys are north-west and south-east, or at right angles to this, except where influenced by local peculiarities. One of the most important of these valleys is that of Fish river and its continuation—the North-east Arm of Upper Arrow lake, which comes in from the north, cutting across the strike of the rocks. The chief valley of the district is that of Trout lake and Lardeau river, which following with considerable exactness the strike of the rock, forms a natural highway between the North-east Arm and the Duncan-Kootenay valley. A similar north-west and south-east valley, farther south, forms a pass between Nakusp on the Upper Arrow lake and the head of Slocan lake.

Character of valleys.

The smaller valleys are deep, narrow and V-shaped; the larger steep-walled and U-shaped. The gradient of the lower part of the valley is usually steep for a few miles, trenched into a canyon near its mouth by the occupying stream. The middle portion has a moderate slope, while at the extreme head it rises steeply to a funnel-shaped basin or a park-like amphitheatre. These valleys dissect the district into a number of mountain ridges, having in general a north-west-south-east trend, with offsetting ridges at right angles. These mountains are big, blocky masses terminating in rugged, narrow, serrated ridges whose even sky-line is relieved in detail by numerous pinnacles and spires. This even sky-line suggestive of a dissected peneplain, which is a striking feature

Montains.

in a panoramic view from almost any peak, is remarkable in so mountainous a district. It seems to be due to sameness in physical and structural conditions of the rocks over a wide area, with perhaps planation by the Cordillerian ice-sheet. Where the country rock is granite or limestone, the mountains are loftier and the sky-line becomes uneven. A thin band of limestone (known locally as the "limedike") is a conspicuous feature in the topography. It forms wedge-shaped ridges which rise precipitously above the surrounding country, and weather into castellated and fantastic forms resembling the famous Dolomites of the Alps. It formerly was the divide between streams draining into the Duncan and Lardeau rivers, but many of these have now sawn through it by a headward growth. The ridges do not taper off gradually as they approach the valley, but run steeply down to the valley level. The ends of the ridges running into the larger valley have all been truncated.

The Columbia valley is a mile and a half wide from Revelstoke to the head of Arrow lake, and very flat. The river with numerous islands and sloughs winds back and forth between the basis of the mountains. When in flood, large areas of the valley are under water. The head of the lake is silted up with material brought down by the river. The shores of Arrow lake rise somewhat precipitously, especially in the east, for the first few hundred feet, where a rock-terrace of varying width occurs. Above this, the slopes are again steep. The mountain slope on the north of the North-east Arm is precipitous. The head of the Arm is silted up by Fish river; in high water its delta is flooded so that high-water and low-water maps of the head of the Arm differ very materially. The Trout lake-Lardeau valley from Beaton, rises about 1,000 feet in the first three and a half miles. From the first lake to Trout lake its slope is so gentle that the divide between Staubert creek and Trout creek can only be detected by the flow of the water. Trout lake, which occupied the central stretch of the valley is a fiord-like body of water about 18 miles long with an average width of about half a mile. The head of the lake has a straight gravelly beach. Along the west side, the beach is continuous to Five-mile creek. The shores for the rest of its length are precipitous except where tributary streams enter. There fans project out into the lake. The valley which is remarkably straight, contracts near the lower end of the lake, from which the Lardeau river issues through a rock channel. The lower part of the Lardeau valley has a low gradient. Numerous soundings were taken of Trout lake, which proved the bed to be flat transversly, and basin-shaped longitudinally. The shores run down at an angle of about 45 deg. The depth of the

Trout lake valley.

main body of the lake is about 700 feet, the deepest point, nearly opposite Eight-mile creek, being 765 feet. At the head, the bed drops rapidly, but toward the outlet it gradually rises; in the narrows it varies from 120 to 200 feet, and is 96 feet deep at the outlet. Its depth is thus greater than any found in the Arrow lakes or in Kootenay lake, though not so great as that of Slocan lake.

The deepest point ascertained in the North-west Arm of Upper Arrow lake was 550 feet—about a quarter of a mile east of Whiskey point.

Water-powers.

Since most of the valleys are hanging, with respect to the valleys they are tributary to, the streams occupying them usually debouch through canyons, at the heads of which are waterfalls. Thus the district is plentifully supplied with water powers for local purposes. On Fish river and Lardeau creek this feature is accentuated by bands of hard rock near the mouths. Thus, while the valley of Fish river is wide and flat above Camborne, between this town and its mouth it is constricted to a narrow gorge with steep gradient. A band of silicous rocks through which it cuts is a contributory cause of this. The smaller valleys are occupied by mountain torrents, the large by lakes or large swift-flowing brooks or rivers. Owing to the heavy precipitation, particularly as snow during the winter months, the brooks are well supplied with water during the greater part of the year.

GLACIERS AND GLACIATION.

Glaciation.

While the topographical features of the district are manifestly due to the erosion of a region of uplift by river action, there is abundant evidence that the resulting features have been modified by the action of ice. The tops of the ridges have been bevelled off and cirques and basins scooped out. The larger valleys where ice could act, have been changed from V-shaped valleys to steep-walled U-shaped ones, the ends of the ridges truncated so that they rise abruptly from the valleys like gigantic cut-banks. The beds of these valleys have been scoured and deepened, so that the tributary gorges lie above as hanging valleys. Transported boulders are scattered over the mountain sides and on the ridges; rock surfaces are scored, fluted and striated. All the higher mountains carry numerous snowfields and glaciers, on the southern exposures as well as on the more protected ones. Some of the glaciers and snow-fields are several miles wide. The distance to which the glaciers descend depends upon the size of the snow-field, the declivity, exposure, and like factors; but few, if any, get below 6,100 feet, and most of them terminate at about 7,000. From the small terminal moraines, in some cases lying beyond the end of the ice, it is

to be inferred that the glaciers have retreated rapidly. This conclusion receives support from evidence that the lower parts of the valleys were recently occupied by ice. Thus Pool Creek valley must have been occupied by a glacier as far as Camp creek at no remote period. The valley is U-shaped with steep walls (50° and 55° respectively), and although some tributaries enter it and snow-slides are numerous, little debris has as yet accumulated in this part of the valley. One tributary stream runs across the valley to join Pool creek over a bed of boulders 10 or 12 feet above the level of the valley, but this raised bed is only a few feet wide. The glaciers have, however, retreated little during the last few years. In one case trees were found growing close to the end of the glacier. The present glaciers are therefore merely remnants of large valley glaciers. In the country to the north and east these glaciers are still of large dimensions. Though comparatively small, the glaciers of this district have considerable thickness. Some are one hundred or more feet thick, even at their lower terminals. They are traversed by numerous crevasses, which makes travel over them somewhat dangerous. In summer, at least, their movement is rapid for the streams which issue from them are charged, especially during the day, with rock-meal from abrasion, and the grinding down of their ground moraines. At the head of Bear creek, where a glacier from Pool ridge discharges over a precipice, each day while we were camped there, the thunder of ice-masses breaking away from the end of the glacier would be heard, so that the movement of this ice-mass must have been a considerable number of feet per day. At night the movement seems to be somewhat arrested. These valley glaciers have produced rock basins and cirques at the head of the streams, but in slates and schists these are usually not well preserved, unless the glacier has only recently vacated them, the stream altering their forms to funnel-shaped basins. For this reason, if for no other, well-formed cirques are less common than in granitic rocks. While some of the glacial phenomena are accounted for by the action of local glaciers, many of the observed facts can only be explained by the action of a large ice-sheet travelling southward, which covered the whole country with the possible exception of some of the higher peaks. Evidences of this ice-sheet which Dr. Dawson has called the Cordilleran glacier, are to be found all over southern British Columbia. The local glaciers may be considered as relics of this former ice-sheet. The direction of the lower part of the ice mass was controlled by that of the larger valleys which it filled. It flowed southward through them. In theses the striation is therefore parallel to the sides of the valley. The upper part of the mass, however, was only slightly effected by the topography, so that the striation produced by it on the high ridges and peaks give the general

Movement of the glaciers.

Cordilleran ice sheet.

course of its movement. On Sproat mountain, which is 8,000 feet high, and which is cut on all sides by deep valleys, the rocks are beautifully fluted and polished by ice flowing in bearing of 123° as proved by several of the criteria for recognizing the direction of ice movements. Crossing the ridge at the head of Mohawk creek, at an elevation of over 7,000 feet, the glacial striæ run 127° and 137°. These also, from the local topography, could not have been produced by local glaciers. Boulders of a porphyritic granite which occurs about 20 miles north, are found here and at about the same elevation on the Pool-Lardeau Creek divide. The direction of movement of the Cordilleran glacier in this district, therefore, corresponds closely to that observed for it in other parts of southern British Columbia, where the average direction is about S. 30° East (Astr.).

There is strong evidence of the important effects of abrasion by this ice-mass. Some of this evidence has already been referred to in describing the fiord-like character of the larger valleys, the production of high-hanging valleys etc. A characteristic result is the production of lake basins. The Trout lake Lardeau valley contains three of these, that of Trout lake being the most important. Trout lake, as we have seen, is 765 feet deep, has a rock lip, and there is a rock divide above its head. There is no evidence of important faulting here, but every indication that the valley bottom is a huge 'dug out.' The 'lime dikes' are much more precipitous on their southern faces than on their northern, that is, on their southern face the slates have been much more heavily eroded. There are no differences in the character or attitudes of the beds to explain this fact, which is most readily accounted for by the plucking action of the Cordilleran glacier. A pot-hole occurs in the rocks on the south-west shore of the lake below American creek, which has probably been produced by an englacial stream.

Terraces.

A little boulder clay occurs under the gravels at Arrowhead. Terraces of silt and gravel occur at a few protected points, particularly along the Lardeau river valley. The highest one observed was at an elevation of about 3,000 feet. They are not so numerous, nor do they reach the elevation of the terraces in the more southerly and less rugged parts of British Columbia, but this is easily explained by the character of the country and the greater erosion.

VEGETATION.

Timber

The larger valleys and mountain sides are, or have been, well forested with valuable timber. Pine, hemlock, Douglas fir and giant cedar and tamarac, are the most important trees from an economic standpoint. The boles are of large diameter and are straight and tall.

In the smaller valleys, and at points, in the larger, the numerous snow-slides have cut swathes through the timber. In some places they keep the mountain sides and valley bottoms swept bare. The timber line has an altitude of about 7,500 feet in favourable locations, but usually the accumulations of snow, snow-slides, etc., prevent timber from growing in any quantity much above 6,000 feet, and in many places less than this. Except where snow-slides cut away the timber, allowing a rank growth of grass and mountain weeds there is no horse-feed at the lower levels. Higher up where timber grows in park-like clumps, and above timber-line, the feed is usually excellent. Undergrowth is dense in the timber up to about 5,000 feet. Owing to the heavy precipitation, forest fires have not done as great damage to the timber here as in some other parts of British Columbia. The destruction by forest fires might in part be prevented were it not for the apathy of the people toward the loss of this valuable resource. Unfortunately, many regard this mode of deforestation with approval as aiding prospecting. Electric storms are, however, an important source of fires. While camped on Arrow lake, four separate fires were started within a radius of 8 miles in an arc of 80 degrees, by one thunder storm. Had it not been succeeded by a couple of days' rain, much valuable timber would have been destroyed. On several occasions I have seen bad fires started in this way in the mountains—sometimes by electric storms that were unaccompanied by any rain. Most of the valuable timber has been appropriated on Upper Arrow lake and its tributary valleys and on Fish river and Trout lake valleys. Saw-mills are in operation at Arrowhead, Comaplix, Trout Lake City, and a couple of large mills to saw lumber for export are in course of construction at Arrowhead. Timber for mining purposes can usually be obtained in abundance on the spot, unless, of course, the location is above timber-line. Above timber-line, heather and alpine flowers grow in great luxuriance. Some successful experiments in the cultivation of fruit and other crops have been made in the Lardeau-Trout lake and Arrow lake valleys.

Electric storms a source of forest fires.

Rocks of the district.

GENERAL GEOLOGY.

The district is largely made up of sedimentary rocks. These consist of dark slate, with some bands of dark carbonaceous limestone and marls, sandstones, conglomerates, tuffs and rocks formed by the metamorphism of these, as phyllites, micaceous, hornblendic, garnetiferous, schists; spotted, and pyritiferous phyllites, talcose schists, calc-schists and crystalline limestones. But eruptive rocks are also important. Green diorite and gabbro-porphyrite rocks occur, usually nearly or quite parallel to the bedding of the sedimentary rocks. Bands of

greenish chloritic schists which represent these rocks in a squeezed condition are abundant. Dykes of a light greenish, yellow-weathering, porphyritic rock occur through a long belt of country, and granite intrusions occur to the north and south-west of the district, while in places, aplitic and pegmatitic dykes proceeding from them are very numerous.

THE STRATIFED ROCKS.

The shales are dark, more or less carbonaceous rocks, in places somewhat calcareous and merging into carbonaceous marls. They are thinly fissile, with the cleavage parallel to the bedding. In places they are sufficiently massive and cleavable to form roofing-slates. More commonly they are found altered by dynamic, and in places by contact metamorphism to phyllites and schists. The phyllites are usually dark to lead-coloured rocks, the incipient development of mica giving them a glossy or nacreous appearance. A graphitoid phyllite is not uncommon, especially near ore-deposits. At some points, particularly approaching the belt characterized by the 'lime-dikes', cubes of pyrite are plentifully developed, giving the rock a spotted, porphyritic appearance. In places these cubes are one inch in diameter. On Trout lake road a thin coating of quartz is deposited around these cubes. Sometimes thin lamellae of quartz are intercalated through the phyllites. At some points the crystalization is more advanced, and glossy sericite schists result. Hornblendic schists with the hornblende in thin needles, and garnetiferous schists are also produced. The schists become coarsely crystalline and gneissose only near the granite contact and where the rocks are much cut up by aplite and pegmatite dykes. The marly bands when metamorphose produce graphitoid lime-schists, hornblendic schists and light-coloured calc-schists. Some belts, particularly near the "lime-dike" zone, are characterized by light-coloured yellowish and reddish, flecked, soft, friable schists, sometimes with an unctuous, talc-like feel. Small cubes of pyrite, often altered to brownish limonite, are frequently scattered through the rocks.

Interbanded with the slates are a number of limestone beds. When weathered, these are usually dark carbonaceous blocky rocks. On the Beaton-Trout lake wagon road, a couple of miles from Beaton, (at the north-west corner post of the Albert D. mineral claim) several dark limestone bands occur in the dark slates. These contain numerous poorly preserved fossil remains. They are sometimes represented by scattered calcite nodules. Those that have preserved some of their original forms appear to be fragments of crinoid stems. Near the head of Murray brook a limestone band contains rings with dark centres,

Fossils.

which also appear to be crinoid joints. These are the only fossil remains so far found in the district.

Marble.

When metamorphosed, the limestone becomes white and crystallized. Some of these bands form pure, white, fine-grained marble, in hand specimens at least, resembling the fine qualities of marble used for artistic purposes. The limestone beds which vary in thickness from a few inches to several hundred feet, are distributed somewhat sparingly through the slates and phyllites, except in certain zones. They are more abundant along the north-eastern portion of the district examined, where the thickest bed forms the well-known "lime-dikes." The limestone of the "lime-dikes" is mostly white and crystalline, but some less altered portions are drab or dark-coloured. In some portions it is replaced partly or wholly by white silica; and quartz stringers form a network through it. These outstanding on account of weathering, make it possible to scale the precipitous peaks which would otherwise be quite inaccessible. As is common in limestone, waterways have been dissolved in it, forming caverns, natural bridges, winze and tunnel-like openings in which dog-tooth and nail-head spar, concretionary limonite and large masses of concentric, radiated arragonite are developed. The arragonite is of beautiful shades of honey-yellow, green and buish.green, and can be obtained in masses as large as 1½ x 1 foot. The slates, phyllites and schists are also silicified in places, and have quartz veins, lenses and stringers developed in them. At several points along the mineralized belts, massive quartzites occur. On the north slope of Silver Cup mountain, where several wide and continuous bands occur, the field evidence points to their being silicified slates. On the Netty L. wagon road, at the Mabee Tunnel, an ovoid mass, twenty feet or more long, of a dark siliceous rock occurs, round which the slates are wrapped. Rocks like it in appearance, but in long bands, occur on Gainer creek and other points, but these rocks appear to be indurated sandstones. The bare, dome-shaped hill, north of the head of the North-east Arm consists of a band of highly siliceous rock. A somewhat similar rock occurs on the Ferguson road above Trout Lake City. The field evidence rather points to their formation through impregnation and replacement of the country rock with silica, but the microscope indicates a clastic origin.

Arragonite.

Quartzite.

Conglomerate.

On the north-east shore of Trout lake, near Eight-mile creek, severals beds of conglomerate occur, interbanded with the slate, one over ten feet thick. The angular to rounded pebbles, which range from 2½ inches in size, are of white and rose quartz, and slate, in an argillaceous matrix. Some are elongated, like portions of a squeezed and broken quartz vein. A similar rock along the strike of these beds outcrops on the Trout lake—Beaton wagon road.

Chloritic schists.

Green fissile and fine-grained greyish schists are largely developed in the sedimentary rocks almost everywhere in the district. At most points their perfect foliation parallel to the dip of the sedimentary rock gives them a resemblance to stratified rocks, but they possess a much greater specific gravity than the latter. The thickness of the same bed varies when followed along the strike, and a large band is apt to divide into several smaller ones with phyllites between. At several points, as at the head of Menhinick creek and Murray creek, similar rocks are produced by the alteration of dykes of a basic eruptive, which are often intercalated in the stratified series. These schists are therefore in all probability altered eruptive rocks.

ERUPTIVE ROCKS.

Gabbro porphyrites.

At a number of points, dykes and masses of green rocks occur concerning whose eruptive origin there can be no doubt. In the present summary, they will be referred to simply as greenstones. At the head of Menhinick creek the greenstone is a heavy mottled gabbro with long green pyroxene crystals, plagioclase and a dark brown mineral with good cleavage. On the ridge between Gainer creek and Cariboo creek, dykes of a somewhat similar rock occur which fork and send tongues out into the slates, altered near the contact; although in general the dykes conform in direction to the dip and strike of the formation. The greenstone at the head of Murray brook is more dioritic in appearance, consisting of hornblende, biotite, plagioclase and some pyrite.

Diabase schist.

In almost all, if not all of the mineralized zones, a green, yellow-weathering rock occurs. Frequently it is schistose, somewhat resembling the chlorite schists, but differing in colour, in the occasional development of serpertine, and in its characteristic weather crust. Sometimes it remains more or less massive and, if large, shows a marked porphyritic texture in the centre of the band, while the borders remain fine-grained. While conforming closely to the dip and strike of the enclosing rocks, it does not always follow them. From its weathering and its high content in lime it is usually called a dolomite, but there is no question that it is an eruptive rock, occurring in the form of sheets and dykes. Its texture alone, where unaltered by mashing, would be sufficient to prove this, were no other evidence obtainable. Microscopic examination points to its having been a diabase, but it now consists of a mixture of quartz, sericite, serpentine and carbonates. It will be referred to as diabase schist.

Granite.

The granite which extends along the south-western edge of the area examined is a rather fine-grained, light-coloured, acid granite, consisting

of quartz, white to slightly reddish orthoclase, white plagioclase, sometimes altered to epidote, and a small quantity of a coloured constituent, which is sometimes biotite and sometimes hornblende. It is full of little cavities formed by contraction on cooling (miarolitic structure). Fine-grained aplite dykes and coarse quartzose pegmatites are abundant in many localities near the granite mass. Coarse-grained porphyritic granodiorite (tonalite, the Nelson granite of the West Kootenay sheet) occurs up Fish river to the north, and numerous glacial erratics of it are scattered over the Lardeau district.

AGES OF THE ROCKS.

The geological ages of the rocks which have been described, could not be definitely determined by the work done this summer. The oldest rocks are those of the sedimentary series. They contain fossiliferous bands which, however, are useless for determining the horizon of the rocks. They are almost certainly palaeozoic and probably about carboniferous. No doubt they correspond to the Slocan series of the West Kootenay district. The greenstones, and therefore, in all probability the chloritic schists, are later than these, but there is no evidence as to their exact age. The diabase schist is newer than the green schists. The granite, I think, belongs to the same intrusion as the Valhalla of the West Kootenay sheet. If so, it is a comparatively late rock, possibly Cretaceous or Tertiary. The only definite evidence regarding its age obtainable this summer, was that it is later than any other Lardeau formation, and it is a very fresh-looking rock.

DISTRIBUTION OF THE ROCKS.

Distribution of the rocks.

The distribution of the rocks can be referred to only briefly in this preliminary report. At Revelstoke the rocks consist of schists, gneisses, impure crystalline limestones, pegmatites, granites, etc. That is, the sedimentary series is much cut up by granitic intrusive rocks and is highly metamorphosed. The same holds true on the Columbia river and upper part of Upper Arrow lake. Masses of granite and their dykes, many of them between beds of the stratified rock, are numerous. A large mass of granite occurs at Saw-mill point, extending southward to near Halcyon. The main body of granite occurs between Arrow lake and Trout lake, forming the greater part of the Lardeau-Arrow lake divide. It extends south-eastward over the Trout lake slope forming the heads of the tributary brooks, and about Rock creek comes within a mile or so of the lake. From hence its contact is more southerly, so that at Poplar creek it is found about 10 miles up the

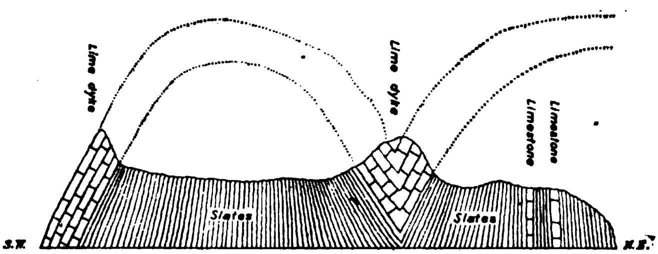
brook from the Lardeau valley. Further south it appears to attain even larger dimensions. The Trout Lake valley, the North-east Arm and the country between Fish river and the Columbia, are largely made up of the dark slates and phyllites with some limestone bands and a little of the greenstone and green schists. The strike of the beds is about 280°, so that these rocks extend as long bands about north-west and south-east across the district. Between the north-east arm and Camborne an important band of the green schists crosses the Trout lake–Ferguson wagon road and the south-west face of Silver Cup mountain. They are also important on the Lardeau river. At Camborne and for a little distance north is a band of slates and phyllites, with dykes of the diabase schist. This band extends south-easterly across the country, crossing Beatrice mountain at the head of Mohawk creek, over Nettie L. mountain, and over the north-east slope and summit of Silver Cup mountain. It crosses the Lardeau river about Tenderfoot creek, and continues through Poplar creek. Northeast of this band, the green schists are again developed, giving place a little farther north-east to the "lime-dike" series which consists of a mixture of slates, phyllites, schists, and some greenstone dykes. Some dykes of diabase schist and important limestone bands also occur. This series, easily traceable on account of the way in which the heavy band of limestone withstands weathering, can easily be followed across the whole length of the district in a direction of about 285 degrees. This formation is met with a short distance up Gainer creek, at the head of the North Fork of Lardeau creek, and the heads of Pool and Lexington creeks.

ATTITUDE OF THE ROCKS AND STRUCTURE OF THE DISTRICT.

Geological structure.

Since there is a close resemblance between the stratified rocks across the district, except in the degree of metamorphism they have undergone, since the greenstone and green schist bands are not always continuous and uniformally interbanded with the stratified rocks, and since there are few well-marked horizons, it is difficult to make out the structure of the district. In the greater part of the district the rocks are tightly folded along axes running approximately 280°. The axes pitch northward in the northern part of the district. At many points they are compound folds, the main arch consisting of a number of anticline and syncline folds (anticlinorium). This structure is further complicated by the intrusion of eruptives and at a few points at least, by faulting. In the northern part of the district near the Columbia the folds are more open. Mount Cartier and the mountains along this range appear to be on the summit of an anticlinorium, the rocks

dipping north-westward on the Columbia slope, and at a comparatively low angle north-eastward on the eastern slope. Around the Northeast Arm the beds are much disturbed by granite intrusion and consequent minor faulting. Throughout the rest of the district the strike is remarkably uniform. (between 250 and 300 deg. but mostly 280, which is about the average of all readings) and the dip pretty constantly northward at a high angle, except where influenced by minor folding. Trout lake valley appears to be on the south-westerly limb of a large, slightly overturned anticline. The conglomorate seen here, which might form a key horizon for working out the structure, was not seen elsewhere. At the head of Gainer creek the structure is revealed by the "lime-dikes." The first (most south-westerly) dyke is formed by the outcropping of a limestone band in the southwest limb of an appressed anticline. A subordinate anticline and syncline with the anticlinal arch eroded, the syncline still remaining, forms the second dyke as shown in the following diagram. Folding and faulting.



SECTION ON RANGE EAST OF PORCUPINE CREEK SHEWING LIME-DIKES

A few miles to the south-east, on the ridge east of Cariboo creek, the the minor fold is a syncline and the major anticline is slightly overturned so that the limestone band dips a trifle northward.

The north-western limb of this great fold probably occurs away to the northwest of the West Fork of the Duncan. where a range appears to be composed of limestone. A second structural feature of great regularity and importance is the jointing at right angles to the strike, which with the bedding planes, cuts the rocks into rectangular blocks. These two structural features determine the chief topographical lines. Importance of jointing planes.

LANDSLIDES.

On the 28th of February, 1903, a mass of rock broke away from a precipitous bluff on the northwest side of the Northeast Arm, about two miles from Arrowhead. The base of the break is about 4,470 feet above sea, or 3,050 above the lake. The top of the break is about Arrowhead rockslide.

900 feet (estimated) above the base, or 3,900 above the lake. The width of the mass was estimated at about 300 feet and the average thickness perhaps 30 feet. It is probable therefore that at least 600,000 tons of rock broke away. It fell against the side of a funnel-shaped depression in the rock, out of which it ran as a narrow stream down a steep draw to the lake, which is here very deep. A small fan was formed at the base of the draw. The lake was frozen at the time, but the sliding rock of course broke the ice, and caused a wave which was estimated by the officers of the steamer *Kootenay*, to be about 6 ft. high. The tug *Revelstoke* was thrown up on shore and drawn back three times by the waves, and the hulk of the old steamer *Nakusp*, which lay sunk at Arrowhead, was tossed about for a few moments on top of the waves before sinking once more. Had it not been for the shoulder of rock which broke the fall of the slide rock, the wave would probably have been destructive in its violence. The rock composing the bluff consists of phyllite, striking approximately east and west and dipping, where the break occurred, at an angle of 50 deg. north. The rocks have a strong east and west jointing with a dip of 60 deg. south. Along the dip of the rock and the dip of the joint planes, the mass broke away in a zig-zag line, leaving an almost perpendicular face (considerably over 80 deg.). Behind this steep face are several open joints which will probably occasion further slides of small dimensions. As the rock-mass broke away largely across the beds, the Arrowhead slide would be classified as a Bergsturz like the great Frank rock-slide. Compared with the latter, the Arrowhead slide is of course diminutive. The causes of the slide were wholly natural. The rock-mass was in a state of unstable equilibrium, dissected by divisional planes, along which it was easily separated. The ties binding it to the shoulder of the mountain were gradually snapped by the action of atmospheric agencies, perhaps assisted by the earthquake tremor of 1901, until finally they were unable to bear the additional weight of the winter snow and the mass broke away along these divisional planes. Landslips have occurred in several other points in the district examined.

Attractions for tourists.

The grandeur of the scenery, the ease of access, the opportunity for mountain climbing, hunting and fishing, and of becoming acquainted with the characters of a western mining camp, should attract tourists and other visitors to the Lardeau. Fair hotels and transportation facilities already exist.

DEVELOPMENT OF THE DISTRICT.

The Lardeau country has been recognized as a mineral district for some time. Claims were located near Comaplix on the Northeast

Arm as far back as 1888, and the Lardeau itself was prospected and staked ten years ago. From that time on, prospecting has continued and the development and opening up of the district have gone slowly forward. But the district has not received as careful attention from either prospectors or mining men as its mineral indications would warrant. Several causes have contributed to this. The rugged nature of the country, its isolation and consequent distance from smelters have made it impossible to handle anything but the richest ores; prospectors decided that it was a silver-lead district only, and searched for nothing else; the depression in the silver-lead markets had a strong retarding influence on the young undeveloped district; many claim owners in view of the high assays obtainable and regardless of the great cost of mining and transporting the ore, held their claims at prices that were prohibitive in an undeveloped district where so many natural difficulties had to be overcome. However, the district is now easily accessible and, in many parts, well opened up with roads and trails which greatly facilitate prospecting. A number of claims are now opened up and provided with the means for handling ore, and in some cases, treating it on the spot. With the successful operation of these and the recent discoveries of rich gold ores on Poplar creek the past summer, it is to be anticipated that the district will soon receive more careful attention from both prospectors and mining men.

Developement of the district.

TRANSPORTATION FACILITIES.

The Lardeau district can be entered from the Upper Arrow lake or from Kootenay lake, the steamer connecting with the Arrowhead branch of the C.P.R. and the Arrow lake steamers run to Comaplix and Beaton at the head of Northeast Arm. From these points wagon roads, with stage lines, run to Camborne, the centre of the Fish river camp. From Beaton, a wagon road also extends to Trout Lake city at the head of Trout lake, and from thence a wagon road runs up Lardeau creek to Ferguson and Ten Mile. Stage lines operate between Beaton, Trout lake and Ferguson. A steamer connects Trout Lake city with Gerrard at the foot of the lake. From the latter, a branch line of the C.P.R. connects Lasdo, at the head of Kootenay lake, whence steamers run daily to Kaslo and Nelson. From these main lines of travel, trails run up the principal creeks.

Routes of travel.

Mining Geology.

Fish River Camp.

This camp, situated on the lower part of Fish river, was located as a silver-lead camp, but at present the principle development is confined to gold leads. The ores occur in two zones. Camborne is situated on the south-western edge of one of these which extends north-westward up Menhinick creek and south-eastward across Pool and Mohawk creeks, over Great Northern mountain to Ferguson camp. Its extension south-eastward from the latter camp will be referred to later.

Mineral belts. This zone consists of a somewhat narrow belt of slate and phyllites cut by the greyish-green, yellow-weathering diabase-schist lying between somewhat broad bands of the green schist. In width and continuance this zone is somewhat irregular, owing to the nature of the green schist already alluded to, which may divide it into a number of subordinate bands, but in general it is easily traceable across the country. Farther to the north, at the head of Pool and Lexington creeks, and on Boyd, Kellie, McRae, Bullard and McDougal creeks is the "lime-dike" series—the second mineralized zone. This runs with considerable regularity south-eastward. The green schists, so far observed, contain no ore bodies. A long line of claims has been staked all along the lime dyke series. The ores so far found are mostly galena with some blende, tetrahedrite, a little copper and iron pyrites, with quartz, calcite, siderite, and some sericite as gangue. Some of the ores carry high silver values, but some, as the Alma, on Pool creek, are large, low-grade ore bodies. Many of these claims have been crown-granted and are now lying idle. Little work of any kind was being done on this belt during the past season, attention being largely confined to the more southerely zone.

Eva gold lead. Claims were located some time ago on this belt for silver-lead. In 1900 an inexperienced prospector discovered a quartz vein with some specks of galena on the lower slope of Lexington mountain, between Pool creek and Fish river, which he staked as a silver-lead claim. Assays revealed a high gold content, and a number of gold claims were staked on this lead. The Imperial Development Syndicate, Limited, of Nelson, was formed to take over and work some of these claims, under the management of Mr. A. H. Gracie. After some development, the Eva group was sold to the Calumet and B.C. Gold Mines, Limited. The Imperial Syndicate is now exploiting the Cholla group.

The main lead has been followed from Fish river south-eastward over the shoulder of Lexington mountain for about a mile, and it probably extends to Pool creek.

Eva Group.

Eva mine.

On this group, now being operated by the Calumet and B.C. Gold Mines, Limited, the greatest amount of work on the lead has been done. The lead here consists of two veins, lying in and along two fault planes, connected by numerous cross-veins and stringers. The direction of the lead is about 120°, cutting the formation at a low angle. At the camp level the confining faults are 175 feet apart, and dip 80° away from one another. Since they are converging upwards, at No. 6 tunnel, 500 feet above, they are closer together, being 90 feet apart. Below, at No. 3 tunnel, the west fault changes its dip eastward. The country rocks are spotted phyllites, cut by the yellow weathering diabase schist. The veins are of quartz, carrying siderite and sulphides, the latter usually in small quantities only, together with free gold. The sulphides consist of pyrite, sometimes crystallized in the form of cubes, and pyritohedra, a little galena and zinc blende. In the Eva shaft the sulphides, especially pyrite, are present in quantity. The veins vary in width from a few inches to many feet. Gouge along the faults has usually confined the ore-bearing solutions within these planes and the crushed country rock between them, so that the veins occur along these lines and in the country rock between them. The southerly vein is called No. 1, the northerly No. 2. Large masses of quartz may be developed, especially where cross-veins join No. 1 and No. 2 veins. The cross-veins have not been observed to extend through No. 1 and No. 2 out into the country rock. In places the lead is of solid vein-matter, sometimes banded, and with divisional planes parallel to the walls or to the stratification of the country rock. Sometimes the veins hold inclusions of the country rock, more or less replaced or mineralized by vein-matter; in other places the quartz is deposited in bands between the lines of stratification. The rock between No. 1 and No. 2 veins and the cross veins, is itself often somewhat mineralized with quartz and pyrite, assaying perhaps $2.50 per ton. Slight faults subsequent to the vein formation, sometimes interrupt the continuity of the vein. Gold may be panned from the quartz almost everywhere, but the values are not evenly distributed. At No. 5 tunnel the vein and the cross vein, which form a small cliff with 50 feet exposed, are said to run $90 per ton. The quartz in the winze between No. 5 and No. 3 tunnels is said to sample $73 and the dump $50. Gold occurs, visible to the naked eye, in solid

Vein minerals

Distribution of values.

quartz, in seams in the quartz and along the selvage of a vein. Generally it is in small scales and nuggets ; sometimes scattered thickly through the quartz in particles as fine as needle points. It is often concentrated along the walls of a vein, or round the inclusions. As the walls and inclusions are often highly carbonaceous, the carbon may be responsible for the enrichment. The veins are usually of higher grade where a cross vein joins. Zinc blende is said to be a good indicator of values. The pyrite in the Highland Mary shaft is said to carry as high as $2,000 per ton. Galena may or may not carry gold values.

About 2,200 feet of development work has been done on the claim. Of this 500 ft. has been done on No. 2 vein; the rest consisting of tunnels, winzes, shafts and cross-cuts to No. 2 vein, has been done on No. 1.

The lower tunnel is about 1,000 feet below the Highland Mary shaft and 1,000 feet above the river valley, down to which the vein has been followed, proving its continuance in depth. An aerial tram was being constructed from the lower tunnel to raise the ore over a shoulder of the hill and convey it 4,200 feet to a stamp-mill, which has been built on the north side of Pool creek above Camborne. The mill is well-constructed and well-equipped with ten stamps, resting on a graded rock foundation. The machinery is to be operated by three Pelton wheels run by water, drawn by a flume from Pool creek, giving a 400 feet head. The mill was almost completed when visited by me in August, and is now running, so that the values carried by the run of mine will soon be determined. The operations connected with the Eva group are being carried on under the superintendence of Mr. John Knox, jr., M.E.

Stamp milk.

The Oyster–Criterion Group.

Oyster-criterion mine.

This group of claims, operated by the Ophir-Lade Mining Syndicate, Limited, is situated southeast of the Eva group on the extension of the same lode. As on the Eva group, the lode consists of a belt of fractured country rock, containing several well-defined veins, one of which is probably the Eva No. 2. The yellow-weathering diabase schist which characterizes the Eva lead, is in evidence here also. As in the Eva, while the veins are partly fissure-fillings, replacement of the country rock by vein material has also been important. The country rock, which is mostly lead-gray carbonaceous phyllite, may be seen in all stages of alteration to solid vein-matter. Quartz is developed between laminae of the phyllites. This vein material then eats into

the rock-forming cloud-like masses and the grains of the rock gradually lose their identity. Finally they are completely changed to vein matter, though often with nuclei of the phyllite remaining. In places therefore the lead may consist of a mass of reticulating veinlets of quartz with phyllite inclusions between. The gold is often concentrated around these inclusions, which are frequently somewhat graphitoid; consequently the mottled parts of the vein are often rich. The gold may be visible to the eye, sometimes in rather coarse nuggets, and almost all, if not all, of the vein will pan gold. What has been said of the distribution of gold values in the Eva appears to hold good here. In the Criterion shaft the vein with some phyllite inclusions is 15 feet wide. The Criterion tunnel runs in a northerly direction for 135 feet, when a galena vein, five feet wide is encountered, which strikes 43 degrees. The tunnel then follows the galena vein. This vein lies between two slips, with gouge and slickensided walls. In about 65 feet along the galena lode, the Criterion quartz vein is encountered striking 261 degrees, angle 65 degrees north. The galena vein, here narrowed down to about 1 foot, cuts through the quartz vein and faults it, the eastern limb being encountered 15 ft. farther in. The gouge on the walls of the galena vein continues unbroken through the quartz. The eastern limb of the quartz vein strikes 90 degrees, and dips at an angle of about 38 deg., so that the galena vein fault was not a simple slip, but the movement was a rotary one. A cross cut on the quartz vein 4 to 5 feet wide is said to sample $80 to the ton. About 60 feet beyond the quartz vein, the faults which the galena vein has been following, diverge, the easterly one running 60 deg. while the westerly turns to 18 degrees. The galena vein and the tunnel follow the latter. Three hundred and fifty feet in from the cross-cut the galena vein encounters an east and west fault with a dip of 80 degrees south, which cuts it off completely. A little farther in a second fault is met with. At 525 feet, a quartz vein several feet wide was encountered in the tunnel, striking 295 deg., angle, 80 deg. south. This is believed to be Eva No. 2 vein.

Veins and faults.

In all about 1,600 feet of work has been done on the Oyster, Criterion Group at the time it was visited. The galena vein contains galena, blende, copper and iron pyrites, largely developed, in a quartz gangue. A thin film of a silver-bearing mineral like argentite was also noticed. This vein is said to carry about $10 in gold, beside silver values. From the way in which the two quartz veins are striking they should intersect on the Oyster claim. Near their intersection it is possible that cross veins and other veins may be encountered, and reasoning from analogy, where the veins intersect, increased

Contents of vein.

values may be expected, as in the Eva where the intersection of veins favourably affects the gold content. An aerial tramway has been constructed from the mine to a stamp mill erected on the south bank of Pool creek behind the town of Camborne, 3,500 feet from the mine and 1,500 below it. The mill is a ten-stamp one, to be operated by water-power obtained from Pool creek. The mill, under construction at the time of my visit, is to be well equipped with crushers, vanners, and all the necessary machinery for a gold mill. A compressor to supply power for drills at the mine was also to be installed at the mill. The Oyster-Criterion operations were being carried on under the direction of Mr. James Lade.

Camborne Group.

Camborne group.

This group, situated on Menhinick creek on the west side of Fish river, a short distance above Camborne, has been operated by the Northwestern Development Syndicate; the chief work has been done on the Goldfinch claim, about 1,600 feet above the mouth of the creek. There are several veins of quartz in phyllites that strike 150 deg., angle 60 deg. north, or toward the Eva mine. This mine is often said to be on the western continuation of the Eva lode, since, if the latter crosses the river, this is about where it should be found, but this statement does not admit of direct proof. Be this as it may, it lies in the same mineral zone. The vein, however, so fâr as seen, does not possess great regularity, thereby making exploitation more difficult. The values are not evenly distributed. In some places, the ore is of exceptional richness, specimens being obtained that are full of coarse gold; at other points values are low. The ore consists of white, sometimes watery, quartz with a sprinkling of galena, blende, pyrite and chalcopyrite. The yellow, apparently very pure gold, occurs with the sulphides, particularly alongside the blende, though often with the galena, and also scattered through the quartz. Many of the richest specimens are in contact with the phyllites, and one was seen in which an inclusion of phyllite was itself impregnated with gold. The ten-stamp mill at the mouth of Menhinick creek, connected with the mine by an aerial tram, is operated by water power from Menhinick creek, and has treated some ore, but it was not in operation when visited. The vein-matter as mined was put through the mill—apparently diluting the rich ore with a large amount of lean material. Although no concentrating was done, the extraction is said to have been 90 per cent of the values, showing that these ores are amenable to stamp-mill treatment, and that most of the gold is free. The operations so far conducted on this group, however, do not afford a basis on which to estimate the values of the gold ores of Fish river camp.

Nature of ore.

Other Occurrences.

Beatrice and other claims.

Quartz veins occur on a number of other claims. The Cholla group is being developed by the Imperial syndicate. The veins sometimes stand up like stone fences above the softer phyllites. On the Copper Dollar and the Kingston very large masses of quartz occur which, though of low grade, should be of economic importance if they contain the values they are credited with. At the Beatrice, on the divide between Mohawk creek and the North Fork of Lardeau creek, about six or seven miles from Camborne and five thousand feet above it, is a promising looking vein of quartz, one and a half to four feet wide, heavily mineralized with medium to very fine-grained galena and light brown zinc blende intimately mixed, a considerable quantity of very fine grained tetrahedrite and pyrite in bands through the ore. The ore is said to carry three to eight dollars in gold, up to 280 ounces of silver, and 20 per cent lead. A shipment of 280 tons rawhided to Ferguson is said to have yielded a substantial profit, notwithstanding the long haul. A second similar vein and a quartz vein containing free gold with a little of the snlphides also occur. About 300 feet of work has been done on these veins, but the main operation has been the running of two tunnels from the north base of the hill to eventually tap the silver-lead and quartz veins at that depth.

The country rocks are slate and phyllite so carbonaceous as to blacken everything they come in contact with, striking about 296 degrees, angle 65 degrees north, but much contorted, rolled and slickensided. In the same basin are several quartz veins which may be auriferous.

SUMMARY.

Two classes of ore.

The foregoing description will illustrate the character of Fish river camp. Two classes of ores occur—silver-lead ores carrying a small gold value, and gold quartz ores carrying very small quantities of the sulphides found in the silver-lead ores. Evidence regarding the relative ages of these two classes of veins is not conclusive. The galena vein on the Criterion is evident'y newer than the Criterion quartz vein. On the other hand, it is cut off by a fault parallel to that occupied by the Eva No. 2 vein. These faults are likely to have been formed at the same time. If this is so, the Eva No. 2 must be later than the galena vein; that is, some of the gold veins may be older and some newer than the silver-lead vein. In this case they may all have been formed during one long continued period of mineralization, but during different stages, the mineralizing solutions changing somewhat in composition. Further information is necessary before these points can be

settled. Little development has been done on the silver-lead veins, though some are promising-looking. The work already done on the quartz veins has shown a considerable tonnage of ore, much being of good grade. The veins have been shown to have continuity both horizontally and vertically. At the deepest point at which it has been seen in the valleys, and at the deepest point below the actual surface of the ground yet reached (100 feet on the Criterion, probably deeper on the Eva) the character of the ore remains unchanged. The two new stamp-mills will soon demonstrate whether the whole or the greater part of the vein-matter can be profitably treated. If it can, the future of the camp is assured. But even if only the richer portions of the veins can be treated; if they mill as high as they are said to sample, careful management, judgment, and the close study of the ore, may be expected to be attended by at least a fair measure of success. From the character of the deposits it is evident that there always exists a possibility of striking rich pockets, and that further veins may be encountered, thereby adding to the prospects of the district.

Prospective tonnage of ore.

FERGUSON CAMP.

Ferguson mountain.

Ferguson is the mining centre of Lardeau creek. The mineral zone from Camborne crosses to the Lardeau slope from the Beatrice, and continues over Great Northern mountain, over the spur of Ferguson mountain, between the forks of Lardeau creek and up the north slope of Silver Cup mountain to its summit. On this belt, numerous claims have been located. Three of these will be described as illustrative of this section. The most important mining operations yet carried on in the Lardeau district are those in connection with the Nettie L. and Silver Cup mines, conducted by two English companies, the Great Western Mines, Limited and the Silver Cup Mines, Limited, with Mr. George Attwood, M. E, as consulting engineer, and Mr. Donald G. Forbes, as general manager.

NETTIE L. MINE.

Nettie L. mine.

The Nettie L. is situated on a spur of Ferguson mountain in the neighbourhood of 5,100 feet above sea or 2,100 above the town. A wagon road about two miles long connects it with Five-mile on the south fork of Lardeau creek.

The country rocks are carbonaceous phyllites and slates. The silicious rocks already referred to occur in the neighborhood, also dykes of the diabase. The average strike of the rocks is about 280 deg. but it varies somewhat on account of folding. There seems to have

been developed locally a small canoe-shaped syncline, whose symmetry is disturbed by faulting. While the westerly strike and high-angle northerly dip are most commonly seen, locally any strike and dip may be found according to the position of the point in the fold.

About 6,000 feet of work has been done on this property, principally on the Nettie L. and Ajax claims. Three main ore bodies have been opened up, known as the Main lead, the Cross lead and the Big Quartz vein. The lowest level on the Nettie L. starts in as a cross-cut tunnel southward across the formation, and 300 feet below the uppermost working. It cuts across the big 40-feet quartz-lead which strikes southeast, and continues to the main lead, about 670 feet in. It then follows the main lead eastward about 800 feet. At the end of this drift the quartz lead has come in contact with the main lead. This level is connected through to the upper workings on the lead. The quartz lead cuts across the formation, and the main lead, while nearly following the strike of the rocks, is independent of their bedding. The walls of the main lead are sometimes slips. Stringers run off into the country rock which is fractured and traversed by slips. There are two levels above this lower one. On the surface, near the upper tunnel, the cross vein coming in from the southeast, turns to 321 degrees and then round to 2 degrees, which course it is following when cut off by the slip, forming the south wall of the main lead. In the second level it is still cut by the main lead, but in the lower workings, it is said to angle round and become parallel to or join the main lead. Its relationship to the bedding of the rock could not be solved beyond doubt, on account of the fracturing and slipping in the rock, but it appeared to be cutting the formation. On the other hand, its course would suggest that it occurred between the beds forming the end of the canoe-shaped synclinal basin. To the east on the Ajax, at the east end of the drift, ore occurs in seams and reticulating veins following the strike of the rocks. The strike is eastward with a northerly dip, but followed eastward, the beds successively bend northward with a westerly dip; that is, we have here the eastern end of a synclinal basin. Successive portions of the ore following the beds turn northward from their original course. The occurrence of ore on the axes of folds—miniature saddle reefs or saddle reefs inverted—is not an uncommon feature in the minor folds of the Lardeau district. This folding is accompanied by a certain amount of slipping and faulting. The cross lead, as its attitude suggests, may possibly represent ore occupying a similar position at the western end of the fold, but more work will have to be done between the Ajax and Nettie L. before this can be proved. So far the evidence is rather unfavour-

Lower workings.

Upper workings.

Inverted saddle veins.

able to such a theory. The ore consists of quartz, usually heavily mineralized with tetrahedrite, galena, blende, and some copper and iron pyrites. Where weathered, wire silver is sometimes found. Occasionally the various minerals occur as separate bands in the ore. Sometimes the tetrahedrite surrounds masses of blende, and veins and veinlets of copper pyrites traverse the tetrahedrite, so that the order of development of the minerals has been—blende, tetrahedrite, copper pyrites and galena. Calcite and sericite occur in the quartz gangue. The vein material may form a wide solid mass or may occur as numerous reticulating veins and stringers in the rock. While mostly occurring in and about fissures, it may be deposited between the beds. Replacement of the country rock by vein material has taken place, so that all stages of development may be met from a few stringers of quartz to a complete network, and finally the whole rock may be replaced by ore. The rock is usually highly carbonaceous near the ores. Besides silver and lead values, the ores carry some gold. Gold is found in the tetrahedrite and, in the Ajax tunnel, quartz with blende, pyrite and a little galena is said to run $100 per ton in gold. Some assays are said to have run as high as 20 ozs. in gold. About 2,300 tons of ore have been shipped, said to have returned over $121,000 net. The average values are said to be :—Gold, 13 oz.; silver, 149·6 oz.; lead, 26·9 per cent. The ore retains its character and values at the greatest depth yet attained, 300 feet.

Values of the ore.

Shipments were discontinued in June, pending the completion of an 8,000-feet tramway from the mines to the silver mill, under construction at Five-mile, to treat this and the Silver Cup ore. Up to the present time, on account of the long haul by wagon to Trout lake, and the cost of shipping to the smelter at Nelson or Trail, only the higher grade ore could be handled, and a dump of about 4,000 tons of second grade ore is now ready for the mill. It is expected that this and the ore from the large quartz vein can be successfully handled under the new conditions. About 50 men were being employed at the mine. The mine is equipped with an air compressor, etc.

SILVER CUP MINE.

The Silver Cup Group consists of nine claims situated on the north slope of Silver Cup mountain, south of the South Fork of Lardeau creek, about 5 or 6 miles from Ferguson, and at an elevation of rather more than 6,500 feet above sea. About 5,000 feet of work has been done, mostly on the Silver Cup and Sunshine claims. The country rock consists of carbonaceous slates with the usual strike and dip, and dykes of the yellow-weathering diabase schist, which sometimes cut the

Silver cup mine.

slates although generally about parallel to them. The ore occurs in two leads, striking nearly parallel to the formation. The northern lead is called the Silver Cup lead and the southern, the Blind lead, as it is not exposed on the surface. Between the two leads are cross fissures, one of which makes a large body of ore. The ore body usually consists of a number of veins of quartz parallel or nearly parallel to the formation, with a network of cross veins. The ore is localized in chutes, lenticular in form, both horizontally and vertically. Some of these are of large size, one continuous slope being 275 feet long. The chute on the cross vein is 7 feet wide. The chutes occur where cross fissures meet the lead, especially those from the foot wall of the Blind lead and the hanging wall of the Silver Cup. The ground is traversed by numerous slips running in all directions. Some form apparent walls to the lead, but vein matter is usually found beyond them. So far the ore is confined to the slates, though the diabase schist is mineralized with pyrite and one dyke is close to the hanging wall and another close to the foot wall.

Ore chutes.

The character of the ore is similar to that of the Nettie L. Tetrahedrite has been taken out in blocks as large as 18 inches in diameter. Some of the best tetrahedrite has been found at the bottom of the winze in the lowest workings—600 ft. below the highest—showing that the values are not due to mere superficial alteration and enrichment of the vein, but are continuous to a considerable depth at least. Besides the silver and lead values (172 oz. silver and 23 per cent lead) the ore carries $12 per ton in gold. The pyrite in the vein seems to be the chief gold-carrier, but only in quantity when it is accompanied by a little galena. On the upper Sunshine workings pyritic ore with a little galena, not at all resembling a silver ore, runs 175 oz. in silver besides $20 in gold per ton. Up to the present time the cost of mining and smelting has been about $50 per ton, so that only the richer ore could be shipped. A dump of about 4,000 tons of second grade ore has accumulated at the mine, which yields by repeated sampling 60 oz. silver and $8 or $9 per ton gold. It is estimated that the new mill at Five-mile will reduce the cost of mining and extraction to about $10 per ton. If these expectations are realized, not only will the dump yield handsome profits, but large masses of mineralized rock containing stringers of quartz and net-works of quartz veins will become ore.

Character of the ore.

Cost of mining and treatment.

An aerial tramway about 8,000 feet long connects the mine with the South Fork wagon road at Eight-mile creek, about 3,000 ft. below. This tram is used to ship ore and to bring up mine timber, wood and supplies; even the boiler, air compressor and hoist were brought up on it. A second tramway, 15,000 feet long, is being constructed from the mill

to a point on the first to convey ore to the mill. A third tram is to be constructed from the highest working of the mine to the upper terminal of the first tramway.

THE SILVER MILL AT FIVE-MILE.

Mill at Five-mile.

The mill in course of construction to treat the Nettie L. and Silver Cup ores is located at Five-mile on the South Fork of Lardeau creek, about a mile and a quarter above Ferguson. The mill is 216½ ft. long by 76½ ft. wide, or 95½ feet. with the retorting furnaces and stack. It is being built by the Union Iron Works of San Francisco. All the timber used for the mill, houses, offices, etc., is being cut and dressed in a sawmill on the grounds. The machinery is being installed in two symmetrical units, so that ore from each mine may be treated separately throughout the whole process. As this is the first silver mill erected in this district, a brief description of it will be given. The ore is delivered from the respective mines into separate grizzlies through which the fine ore passes to bins, while the coarse rolls to the crushing floor, where there are two Blake crushers. The ore is then fed automatically into two stamp mills of ten 1000-pound stamps each, operated by a 75 h.p. induction motor. The pulp from the mortars is automatically sampled and passed to two sets of Spitzkasten hydraulic sizers, the coarse pulp going to four 10-ft. Dodds riffled buddles; the fines to four vanners. The sulphides are then dried on a drying floor, whence they are delivered by elevators and screw feeds to 2 Howell-White revolving roasting furnaces, at the same time being automatically mixed with salt delivered from the salt grinders. The lead driven off by the roasting may be recovered if desired. The ore is then conveyed to a cooling floor, and ofterwards dumped into ten 5-feet amalgamating tanks, through the bottom of which steam is injected to assist in amalgamation. The charge is next run to five 8-ft. settling tanks. After leaving the settlers it is strained, the quicksilver being elevated and run back to the mercury tank supplying the amalgamating pans, and the amalgam taken to the retort-room, where there are two amalgam furnaces. The quicksilver driven off from the furnace is elevated and returned to the mercury tank. Provision may be made for saving the copper if sufficient quantity is present. The power plant, in a separate building, is supplied with two Pelton wheels, electric generators, transformers, etc. The power is supplied by water brought by a 3,700-ft. flume from Lardeau creek, and delivered at the power house under 145-feet head.

Treatment of the ore.

THE TRIUNE MINE.

The Triune mine is situated a short distance south-east of the Silver Cup, only a small ridge and the head of a gulch separating them. In elevation, it is about 1,000 feet higher than the Silver Cup terminal. It is one of the most picturesquely situated mines in British Columbia. The tunnels run into the face of a cliff under a small glacier, a rope being used to assist in the ascent to the lower tunnel. The upper tunnel is reached through an up-raise from the lower. A considerable amount of work has been done; the lower tunnel has been driven in 300 feet, the upper tunnel 150 or more; the total amount of work done aggregating possibly 1,200 lineal feet. Triune mine.

The country rock is slate with a strike of 272 feet and a dip of 70 degrees north, but suffering local disturbances. With it occur a large number of dykes of the diabase schist. The main lead is a strong vein of somewhat variable width, in places as much as 8 feet wide, but usually not exceeding 4 feet. It is found in the slate with a diabase dyke near the foot wall, the vein sometimes even traversing the dyke. A second parallel vein occurs in a band of slates on the south side of the dyke, with the dyke as a sort of a hanging wall. The lead consists of solid mineralized quartz or stringers and veinlets of quartz reticulating through the country rock. Hence there are often small horses with veinlets running through them. As the ore is not abundant on the surface of the lower working, it evidently occurs in the form of chutes, as on the Silver Cup. In other respects it is similar in character to the Silver Cup. The upper part of the vein is possibly somewhat richer in grey copper than the lower, but it is also richer in blende and poorer in lead, which is the reverse of what might be expected if much enrichment by surface waters had taken place. The first-class ore is stated to carry $12 to $18 in gold; over 200 oz. in silver and 30 per cent of lead to the ton. The following information regarding the distribution of values through the minerals of the ore was furnished by Mr. Dunn, the superintendent at the mine:— Two veins.

The pyrite will assay $20 in gold per ton. On the surface where the ore is oxidized to 'carbonates' the gold value amounts to $50 per ton. Pure galena will assay $200 per ton in value of all the metals.

A condition rather uncommon for this latitude is found in the upper workings of the mine, that is approaching the bed of the glacier. The ground is here saturated with water in the form of ice. The temperature must remain below freezing the year round, for in midsummer the ground remains frozen and the walls are coated with frost crystals. The water travels downward by melting and freezing, for if a tunnel Conditions due to frost.

is not in use, it fills almost to the top with ice, and stalactites and stalagmites and pillars of ice are formed. When the frozen ore is taken out of the mine and melts, it is stated that it loses 50 per cent in weight, and is reduced to a slime, difficult to handle. Snow-shoes have made a permanent camp impossible, so that the mine has not been operated in winter. Snow-slides also overturned the tramway, more than a mile and a half long, which was put up last year to connect the mine with the wagon road. These disadvantages attendant upon its unique situation, have made an ore carrying less than $100 to count as of second grade. Notwithstanding, it is estimated that at the close of the present season, the output of the mine will have reached a total of $40,000. It might be mentioned in passing that a dyke of diabase near the Triune cabin is somewhat heavily mineralized with quartz, siderite, galena, copper, etc. The Triune is situated on the south-eastern continuation of the mineral belt on which the Silver Cup is situated, and it is quite probable that it is on the same general lead. As the Triune is at a higher elevation and the dip is northward, the lead outcrops farther south than at the Silver Cup. It is not to be inferred that ore is necessarily developed throughout the whole distance, for it has already been stated that it is localized in chutes. This mineral belt extends over Silver Cup mountain, the Cromwell and other claims being situated on it. It probably runs along the range past the upper part of American, and Haskins creeks, but on account of the snow it was impossible to trace it up. A number of quartz veins occur on this mountain, some showing free gold. Some quartz stringers occur containing feldspar as if they were an acid facies of pegmatite.

Triune a probable extension of Silver Cup.

Gold veins on Silver Cup mountain.

A number of other claims are situated on this belt in the neighbourhood of Ferguson, but they have not had as much development, and their description would add nothing new regarding the character of the ore and conditions of mineralization.

Lime-dike mineral belt.

The 'lime-dike' series of rocks forming a belt along the head-waters of the tributaries of the Lardeau, and West Fork of the Duncan, is well mineralized, but on account of the altitude and distance from transportation, development has necessarily been slow. Were it not for the metamorphism which some of the rocks have undergone, and the prominence of limestone, there is little difference between the rocks and ores of this belt and those of the mineral belt just described. They contain numerous diabase and porphyrite dykes and sheets; bands of the green schist are also met with. The rocks are compressed into folds, so that while the strike is fairly constant, the dip varies from north to south. The possible influence of the folding upon the ore bodies should be borne in mind in exploiting the ores of this

district. Somewhat auriferous silver-lead ores, and siderite-bearing quartz veins are found in this belt also.

Badshot claim.

The Badshot, one of the best known groups of claims, is situated on the west side of Gainer creek in the south base of the first "lime-dike." The veins occur in the "dike." The bluish limestone is shot through with veins and stringers of quartz and somewhat ferruginous calcite, generally having a low dip northward. The Badshot vein, several feet wide, dips into the mountain at an angle of about 28 deg. north. Its outcrop along the side of the dyke is plainly visible. The vein-matter consists of somewhat decomposed calcite, quartz, galena, and tetrahedrite. An incline shaft, about 70 feet deep, has been sunk in the vein. A galena vein 18 inches in width and said to run $5 in gold, 225 oz. in silver, and 75 per cent lead, has also been opened up. Galena and tetrahedrite were the only metallic minerals seen in this ore.

Some ore was shipped during the summer from the Mohican, opposite the Badshot on the east side of Gainer creek. On the Ophir-Lade group situated in this belt, the quartzose ore is said to carry high values in free gold.

TROUT LAKE DISTRICT.

Trout lake mineral belt.

Some mineralization has taken place in the Trout lake valley. Quartz veins somewhat mineralized, occur near the Beaton wagon road. A rather strong vein of mineralized quartz occurs on the Lake shore below Abrahamson creek. On the mountain slopes southwest of the valley, isolated groups of claims have been staked, practically along the whole length of the valley, some of them furnishing very promising-looking samples. From the position and number of these locations, this may be considered to form a third mineral belt. That the locations have not been more numerous may perhaps be explained by the difficulties in the way of prospecting, due to the vegetation and to lack of facilities for getting supplies into this part of the district. The Lucky Boy claim on the shoulder of the hill south of Trout creek, about three miles from Trout Lake city, is being developed and is shipping some ore. Several open cuts and one or two inclines have been run on the main vein, which varies from a few inches to several feet wide. In the main stope it pitches south-westward at rather a high angle. But for the most part it is almost horizontal, with perhaps a slight south-westerley dip, cutting almost at right angles the formation, (schist or altered silicified phyllites), which dips north-eastward at an angle of about 85 degrees. There are several parallel fissures which are not so well mineralized. Some inclusions of country rock occur in

Lucky Boy mine.

these and there is evidence of replacement. The quartz is somewhat drusy, and the ore often occupies these druses or occurs scattered through the quartz, in kidney or almond-shaped masses, or as small veinlets. The ore consists of galena, tetrahedrite, zinc-blende, calcopyrite, pyrite and a little native silver. On the surface it weathers to lead and copper carbonates. On the Horse Fly, adjoining the Lucky Boy, the ore occurs in limestone. On the Ruffed Grouse, Copper Chief and Willow Grouse claims, some distance above the Lucky Boy, the same minerals occur. The sulphides reticulate through the quartz as if formed later, or collected by concentration, so that in places it resembles brecciated ore, with the fragments cemented by sulphide. Pyrite is here more plentiful, and masses of pyrrhotite and some molybdenite also occur. The relationship of the metallic minerals to one another is interesting. The galena is found both in and surrounding tetrahedrite; the blende encloses both. Chalcopyrite encloses and forms veins in the foregoing, and pyrite and galena form the matrix for the others. The order of development would seem to be: galena, tetrahedrite, chalcopyrite and pyrite, galena, blende, but from the way in which the chalcopyrite surrounds and eats into the tetrahedrite, it looks as if it was formed by alteration of the latter, and from the frequency with which it occurs as a thin seam between tetrahedrite and pyrite, as if the action of the iron sulphide on

Tetrahedrite.

the tetrahedrite might have induced this reaction. The practical bearing of this lies in the fact that since the tetrahedrite was one of the first formed minerals, there is firmer ground for our belief that the rich mineral will continue at depth. Work was progressing on the Ethel mine on the north-west side of Glacier creek.

Some good showings of ore are said to occur on claims up Five-mile and Canyon creeks, but the season was too short to allow of a trip being made to them. Some ore was being packed to Trout lake from the American mine at the head of American creek, a claim located on the central mineral belt. The claims on the Trout lake district enjoy the great advantage of being near transportation facilities, permitting a lower grade ore to be shipped. The cost of freight and smelting ore delivered on Trout lake is from $16 to $18 per ton.

THE POPLAR CREEK DISTRICT.

Poplar creek district.

The basin of the Lardeau river, below Trout lake, is now usually referred to as Poplar creek district, since the excitement and rush into the district this summer was caused by discoveries about the mouth of Poplar creek. The district is not altogether new to prospectors; some of the most highly-prized claims, such as the Goldsmith-

were staked ten years ago and abandoned, and some prospectors have been at work ever since. When the construction of the railway from Lardeau to Trout lake was decided upon, the district received renewed attention. The Lucky Jack, situated on the railway line, which has been responsible for the greatest part of the enthusiasm over the district this summer, was located in 1900 by Augustus Buffalo, and abandoned after two assessments had been done. Another claim, now well spoken of, is the Dominion at the mouth of Cascade creek, the first creek below Poplar, which was located by the same prospector, the same year, and is still held by him. But until recently, the Lardeau was regarded as purely a silver-lead district. Yet gold has been known to occur here for several years, but not until this summer did the public become agitated over the fact. In 1898 H. Rodgers and Henry Schmidt located the North Star and other claims on the north side of Rapid creek, the first creek above Poplar, about 800 feet above the Lardeau valley. It was located on account of a showing of galena, but was soon found to be auriferous. About 60 feet of work has been done on it every year since. In 1901 John Winquist located the Spy-Glass, about 12 miles up Poplar creek, which, it is said assayed $120 in gold, besides high silver value. In 1901 Marquis and Gilbert located the Ochre and Ophir claims on the north side of Poplar creek about a mile from the mouth, and 640 feet above the Lardeau valley. In 1902 Marquis located Gold Park, adjoining these claims, and on it last June specimens containing visible gold were found. These were exhibited in Kaslo soon after and started the rush to the district which has resulted in the discovery of numerous quartz-veins yielding exceptionally rich specimens of native gold. All of the ground about the mouth of Poplar creek has been staked; some of it many times over and locations have been made from the second crossing below Cascade creek to beyond Tenderfoot creek. A town is springing up at the mouth of Poplar creek. **First gold discoveries.**

The rocks of this lower part of the Lardeau basin are similar to those found in the upper, and consist of greenstone and green schists, slates and phyllites, with a few limestone bands and dykes of the yellow-weathering diabase and schist formed by its deformation. The greenstone seems to be more heavily developed here than above, and the diabase dykes to be larger and more numerous. But time did not permit of making a detailed examination of the whole district. The veins occur on a belt of slates and dykes which crosses the Lardeau river from the north-west, above Tenderfoot creek, and extends south-westward, nearly parallel to the river, across Rapid, Poplar and Cascade creeks. On account of the snow the Silver Cup belt could **Rocks of Lardeau basin.**

not be followed south-east across the Silver Cup mountain, but there is little doubt that the Poplar creek belt is its south-eastern continuation. This supposition is based on the character of the rocks and ores, the strike of the rocks and the position of the belt relative to other formations. Thus the 'lime-dike' series is seen up Lake creek, showing the rocks to be angling toward the river. In Rapid creek, boulders of a conglomerate similar to that found in Trout lake, afford pretty good evidence that this band is to be found up Rapid creek, that is, it has crossed the valley and is now away to the south-west. The veins are similar in character to those of Fish river and Silver Cup mountain, already described, except that at Poplar creek arsenopyrite is occasionally found. But the introduction of a new mineral at a particular point in a mineral belt is no rare thing. In this part of the belt veins are very numerous. In some places they form a net work. They usually conform to two principal directions. One set runs about 290 degrees, that is, almost parallel to the formation, though the dip may vary, and the second set cross-cuts the formation running nearly north and south. The claims which had received most attention up to the time of my visit were the Lucky Jack, Swede group (Goldsmith), Gold Park, on Poplar creek; North Star on Rapid creek, the Maggie May and Handy groups near the railway at Tenderfoot.

Poplar creek belt is continuation of central belt.

Principal claims.

LUCKY JACK.

Lucky Jack mine.

The Lucky Jack is situated on the west side of the railway about a quarter of a mile below Poplar creek crossing. The main vein is exposed in the hillside about 100 yards from the track, standing out like a wall from the more easily weathered country rock. The country rock is a rusty-weathering grayish schist which proved on examination to be the diabase-like rock in a squeezed condition. It is more or less impregnated with pyrite in small grains and veinlets. The vein is of quartz, two to five feet wide, averaging perhaps three feet, standing almost vertically and with a strike of 338 degrees. A number of other veins occur on the property but most of these have the westerly strike. The quartz is milky to watery white, carrying a little arsenopyrite, galena, and pyrite with, in places, very coarse free gold, liberally splashed through it, in bunches, masses, fibers and plates. The gold occurs in the pure quartz, in the sulphides, surrounding sulphides, with inclusions of country rock or along the walls. Fine gold also occurs in the vein, as in the tunnel which is being run in on the vein. Quartz which contains no visible gold is said to pan well. This vein has afforded many magnificent specimens of native gold, some of the finest ever found in the province. One specimen which we photographed was about 2 feet long

Free gold specimens.

and $1\frac{1}{2}$ feet high and consisted of quartz with coarse gold liberally scattered throughout the entire mass. The owners estimate that specimens containing about $2,000 in gold have been taken from the vein. The values are not evenly distributed; in a large part of the vein no gold is visible though it is said to pan well. The occurrence of sulphides and inclusions of the country rock appear to be favourable indicators of values. Probably the intersection of cross veins will also cause an increase in value. The arsenopyrite is said to assay as high as 325 ounces of gold per ton. Even with the eye a large quantity of free gold can be detected in the arsenopyrite. A tunnel had been started on the vein, and as far as it had gone the character of the vein remained unchanged.

SWEDES' GROUP.

On the south-east shoulder of the mountain, between Poplar creek and the river, about 1,400 feet above the valley, are the Gold Hill and Goldsmith claims, known as the Swedes' group, and just east of these is the Crown King. **Goldsmith claim.**

A large number of quartz veins occur on these claims having a course of about 285 degrees and varying from a few inches to six feet in width. A number of cross veins are also found. They are mineralized here and there with galena, pyrite and spathic iron weathering to limonite. At many points they will pan gold. On the Goldsmith claim on Poplar creek slope a quartz vein 18 inches wide dipping slightly southward occurs in pyritized slates. It is almost parallel to the slates but strikes a few degrees more northerly. The richest specimens yet found at Poplar creek were taken from a point on this vein but at the time of my visit the spot was covered up to avoid the necessity of maintaining a guard. One specimen obtained here was said to weigh five pounds, of which two and a half pounds was estimated to be gold. North-east of this vein, in a dyke of the porphyry a galena vein, which varies from two inches to a foot in width, was exposed for about fifteen feet. A shallow hole has been sunk which shows it to be widening from eight inches at the surface. It is heavily mineralized with galena and some blende, copper and iron pyrites. It is stated to carry high values assaying as much as $5,000, mostly in gold. The galena weathers to white sulphate and carbonate leaving free gold.

On the Crown King, veins are also numerous. For some little distance a vein occurs every few feet. The country rock itself appears to carry gold values. The owners had started to dig in what appeared to be some weathered diabase schist, but this earthy material was found to **Crown King.**

pan well. Some stringers of quartz one-eighth of an inch to two inches in width occur in it containing a little galena. A pan of this quartz and decomposed rock-matter was washed and a large quantity of fine gold and a number of nuggets were recovered.

GOLD PARK GROUP.

Gold Park.

The Gold Park group is situated on the north side of Poplar creek, opposite the Swedes' group and about 640 feet above the town. Several quartz veins occur, from a few inches to several feet in width, carrying the usual minerals and at some points, as below the trail on the Ophir, crystals of arsenopyrite half an inch long. The course of the veins is usually westerly. The country rock is slate on the north and the rusty-weathering schist on the south. Veins occur in both, but the main lead seems to be in the schist. Near the veins the country rock is impregnated with pyrite and arsenopyrite. Free gold has been found in the veins; in fact it was specimens from this group that started the first rush to the camp.

NORTH STAR GROUP.

Rapid creek claims.

This group is situated north of Rapid creek about 800 feet above Lardeau valley. The country rock consists of thin bands of slates with the usual dip and strike between dykes and sheets of diabase and greenstone. Several veins occur, some striking with and some cutting across the formation. Those striking with the formation may cut across the dip of the rocks and in places cut both dip and strike. The quartz is in places well mineralized with the sulphides. About 300 feet of work has been done. At the greatest depth attained the character of the vein was the same as on the surface. The result of development on the Maggie May and Handy groups near Tenderfoot creek is said to be very encouraging.

SPYGLASS GROUP.

Spyglass claim.

About twelve miles up Poplar creek and 3,400 feet above the town, Winquist has located the Spyglass claim on a lead which occurs under conditions somewhat different from those already described. It occurs in a band of slates included within the granite. Ascending the creek a band of granite about a mile wide is crossed before coming to the Spyglass cabin. The claim lies about 800 feet above the cabin in a band of slate. The main mass of granite lies about 1,000 feet to the west. The slate is altered to glossy mica schist and is cut by tongues of

granite and pegmatite. The lead lies in the schist between two of these, striking with the formation, 308 degrees, angle 43 degrees west. The lead consists of a band of quartz from two to three feet wide distributed through and between the laminae of the schists, and replacing them. A great deal of pyrite occurs in the rock and ledge matter. The quartz is somewhat cavernous, and crystals are developed. Within the lead is a pay-streak six to twelve inches wide, heavily mineralized with blende, tetrahedrite, galena, copper and iron pyrites, native silver and probable argentite. Free gold is reported to have been found. The ore runs very high in silver, and, it is said, in gold. Beautiful specimens impregnated with native silver may be obtained from this mine.

PLACER MINING.

Experiment in placer mining.

A number of placer claims have been located on the Lardeau river. A bar below Poplar creek and above Cascade creek, on the north side of the river, 2,600 feet long and 400 feet wide, has been taken up by Messrs. Stead, Gilmore and Moyer, who have commenced operations. Their hydraulic plant consists of a Krough centrifugal dredging pump, operated by a 45 h. p. Case traction engine, and nine sluice boxes provided with riffles, false bottoms, cocoanut matting, etc. On account of the coldness of the water, mercury is not used and satisfactory results are obtained without it. The pump has an intake of eight inches and will handle boulders two-thirds this size. The nominal capacity for twelve men working a ten-hour shift is 500 yards. Work was only commencing and surface rootlets and large boulders were causing some difficulty, but with a pit provided with a grizzly for the intake pipe and a device to intercept the roots, it was expected that these sources of annoyance would be removed. Several pans of dirt from different parts of the bar were washed, which yielded good colours from the size of a pinhead down. Tests made by the company have led them to suppose that the gravel will run from 75 to 80 cents per yard and some $1.25. The results of this experiment are being looked forward to with interest, as, if successful, it will lead to a great deal more placer mining being done.

Encouraging outlook.

Regarding the degree of success which may attend operations in Poplar creek district, nothing very definite can as yet be said. This discovery of gold is an important one. The veins are numerous and strong, are persistent in length and there is good ground for believing, persistent also in depth. In places some of the veins are of exceptional richness. As deep as they have been tested the character of the ore remains unchanged. One most encouraging feature is the extent of mineralized rock and the values that can be obtained from

rock containing only small stringers of quartz, such as that mentioned on the Crown King. Another is the comparatively uniform distribution of values in veins like the galena vein on the Goldsmith. In many respects the ore reminds one of that of the Cariboo at Camp McKinney, which has been operated with good results for many years. A large quantity of what should be good pay ore is exposed on the surface, and some very rich spots occur; but information was not available on which to base an estimate of the run of the mine. The values are not and cannot be expected to be uniformly distributed and what effect the leaner ore will have on mill runs has to be ascertained by actual tests. The prospects are that some of the veins will yield very satisfactory returns. The district as a whole is worth and will no doubt receive careful exploitation. But the success of mining enterprises depends not only on the amount and value of the ore, but upon the business management. It is manifestly unfair to expect a mine to pay satisfactory dividends on over-capitalization of any kind, and it is to be hoped that the promising properties in this district will not be handicapped at the outset by mistakes of this kind.

GENERAL REMARKS.

Mining belts. Mineral occurs throughout the length of the Lardeau district, principally along three belts, a south-western zone on the south-west side of the valley and toward the granite contact, a central zone stretching from the north-west of Camborne to southeast of Poplar, its south-eastern limit not yet determined, and the 'lime-dike' zone stretching south-eastward from Fish river across the head of Lexington and Pool creeks and along and near the Lardeau-Duncan divide, its north-western and south-eastern limit not yet determined. Some mineralization occurs outside these zones, but these constitute the main lines of mineralization. The ores occur in the sedimentary rocks, viz., slates, phylites and limestone, and in the rusty-weathering diabase schist, but no important mineralization was observed in the green schists, or irruptive rocks, except in a few individual cases. The mineral-bearing zones are characterized and may be recognized by dykes of the yellow-weathering diabase (the larger more coarsely crystalline dykes do not produce this yellow coating so readily) which divide the sedimentary rocks into bands of varying width. The veins occur along, near, and in the dykes. The veins have two principal directions, approximately parallel to the strike of the rocks, and nearly at right angles to it. They are usually almost vertical, but vary in the direction of their dip. They are of a composite fissure type. Their direction is largely determined by that of fissuring, but besides fissure filling there has been consider-

able replacement of the country rock. In places, to some extent, the bedding planes of the rocks have also been utilized for the deposition of ore. The veins have been formed by aqueous mineralizing solutions which have apparently brought up their load of mineral matter from below. The character of the ore is not directly dependent upon the nature of the country rock. Small horses and inclusions of country rock are often numerous in the leads. The relationship of the dykes to the deposits seems to have been largely physical—determining the direction and circulation of the ore-bearing solutions, though perhaps the iron and carbonates of the dykes may have been reached chemically with the ore-bearing solution. The veins may have a connection with the granite intrusion as some of the quartz veins have characters resembling those of the acid series of pegmatite dykes. The magma from with these pegmatites were formed became more acidic and aqueous as distance from the parent granite was gained, and the gaugue of the veins is often rich in feldspar and sericite as well as in quartz. According to mineral contents, the veins can be roughly divided into two groups, the silver-lead veins, rich in metallic sulphides, and the gold veins, poorer in these sulphides. Except in this one respect the veins are very similar. The silver-lead veins carry gold values and are sometimes rich in this metal. The relationship between the two classes of veins is not clear: they may be of the same age and may have been formed by the same processes. On the Criterion, a galena vein is younger than one quartz vein, but may be older than a second; there is some ground for the opinion that they are closely related and they may have been formed during the same general period of mineralization. The vein-stone is quartz with some calcite, siderite, feldspar and a little sericite. The metallic contents, are galena, blende, tetrahedrite, copper and iron pyrites, arsenopyrite, argentite, native silver and gold. The veins are found on the highest summits and in the deepest valleys. The largest number of locations have been made at the higher elevations, probably on account of the better exposures. On the lower slopes and in the valleys the difficulty of prospecting is greatly increased by wash and vegetation. Mining in such localities however, can be carried on at a lower cost. The values are not evenly distributed, but are localised in chutes. They are often concentrated round carbonaceous rock inclusions and along carbonaceous wall-rock and sometimes in it. Some sulphides, particularly zinc-blende, are often a good indication of values. Chutes are generally located at the intersection of veins. Other indicators of values will no doubt be found when further development has been done. A particular effort should be made to find, if possible, a key for recognizing pay quartz by the naked eye where the values are in fine gold. The indications are

Mode of formation of the veins.

Vein minerals.

Distribution of values.

that values will continue in depth; they are unchanged to the deepest level reached in the Silver Cup; the richest mineral, tetrahedrite, is one of the first formed, and blind leads, which cannot have been affected by surface enrichment, carry ore as well as outcropping leads; and the horizontal veins have the same characters as the vertical ones.

GROUND STILL OPEN FOR PROSPECTING.

Where to prospect. Although all the ground at Poplar creek itself is staked, there is still a great deal of promising territory to be prospected for gold. The same belt is mostly open for prospecting north-west of Poplar creek to Silver Cup mountain. On Silver Cup mountain and between it and Camborne there is still some free ground. Anywhere along this belt, gold may be found. Free gold was discovered this autumn on the Winslow, north-west of the head of Seven-mile creek. While it is not certain that the whole length of this belt is auriferous, it is worth examination. The belt south-east of Poplar creek is little known, but may prove auriferous. The south-west belt between the valley and the granite contact is mostly open for prospecting. Some promising silver-lead ore containing gold values, has already been found in this belt. The lime-dike belt may also be prospected for gold. Numerous quartz veins similar to those in the gold camps occur in it, under similar conditions and it is altogether probable that some of them are gold-bearing. The Ophir-Lade group is said to contain rich free gold ore.

Quartz veins and some galena veins occur between Fish river, the Columbia and Revelstoke, but little is known of this district. The quartz veins seen by the writer appeared rather lean and no free gold was detected. Still, a closer examination is necessary before this part of the country can be pronounced barren and, so far as known, prospecting may be attended with success.

OTHER ECONOMIC MINERALS.

Iceland spar. On a dump of the You-Know-Me claim at Whiskey point, on the North-east Arm of Upper Arrow lake a small piece of calcite so clear and unchecked as to belong to the Iceland spar variety was picked up. If a quantity of this clear unchecked calcite could be found it would be a most valuable discovery. Iceland spar is in great demand for optical purposes and the present supply of the world is practically exhausted.

Asbestus. Some fibrous serpentine occurs on Silver mountain apparently in altered porphyrite. Some fibers are 2 inches long but rather brittle.

Should pliable fibres be found, the cost of transportation is still too great to make a deposit of asbestus in this locality of present commercial value.

Fine specimens of clear quartz crystals are found on the Towser claim below the Silver Cup mine, showing the usual prism and pyramids and the right hand trapezohedron.

Thanks are due to the prospectors and mining men generally for the kind assistance rendered in prosecuting the work. Among those to whom we are particularly indebted are Mr. Cory Menhinick, Mr. A. H. Gracie, Mr. John Knox, Jr., Messrs. Jas. and V. Lade, Messrs. Green and Wilkie, provincial land surveyors, Mr. Geo. Attwood, Mr. Donald G. Forbes, Mr. Barclay Crilly, and many others. Acknowledgements.

Peace River Country.

Mr. J. M. Macoun.

Pursuant to your instructions, I left Ottawa on the 4th of May, and travelling by the usual routes reached Edmonton on the 11th. I was joined there by Mr. William Spreadborough, who acted as my assistant during the summer, and together we drove to Athabasca Landing, where we remained until May 23, when we were enabled to take passage on a Hudson's Bay Company's York boat bound for Lesser Slave lake. After a short delay on the lake, caused by the ice not yet having broken up, we reached the trading post at the head of the lake on June 2. Horses and wagons having been hired there, we drove to Peace River Landing, where I expected to be able to buy horses, but finding none for sale, I was very glad to hire a pack-train for the season, at a reasonable rate, and by this means I was enabled to traverse a wide extent of country, and during the summer I visited every piece of open prairie of more than 5,000 acres in extent and examined every piece of cultivated land in the Peace river region. Report on Peace river country.

A small steamer, owned by the Roman Catholic mission, went down to Vermilion in June, and, taking passage on this boat, I was enabled to see the river-valley from Peace River Landing to Vermilion and my stay at the latter was sufficiently long to permit of my examining the country for fifty miles around that place. As my full report will be published in advance of this summary statement, none but the briefest reference to the results of my season's work will be necessary. I found the valley of the Peace river all that it has been reported to be, but the cultivatable area in the valley itself is so small that it is not worth considering in a report on the whole region. On the upper Full report published.

Peace river plateau, which is from 800 to 1,000 feet above the river and from 2,300 to 2,500 above the sea, the only part that is likely to be touched by a railway for many years, is about 7,000,000 acres of prairie or bluffy country. The wooded parts differ hardly at all from the prairie, as regards soil. This is, almost everywhere, a rich black loam resting on an impervious clay subsoil. This soil is of great fertility but of varying depth. Its fertility is shown by the analysis made of it by Prof. Frank T. Shutt of the Experimental Farm, Ottawa. He reports : 'It was found to have a very slightly acid reaction. Tested for alkali, only traces of common salt were found, though careful search for injurious sodium and magnesium compounds was made. A qualitative examination for lime, showed that the soil was by no means deficient in this element. A partial analysis of the air-dried sample furnished the following data :

Character of soil.

	Per cent.
Moisture	3·44
Organic and volatile matter	11·82
Nitrogen	·471

We have in these results ample and emphatic evidence as to the richness of this soil in humus compounds and nitrogen, equalling in these respects much of the fertile prairie soil of Manitoba and the North-west Territories. Time has not allowed making any determination of the potash and phosphoric acid, but in judging from past experience with soils of a similar humus and nitrogen content, this soil in all probability is well supplied with these constituents.' The country south of the Peace river, including Grande Prairie, is probably a little warmer than that to the north of the river between Dunvegan and Peace River Landing.

Cattle-raising.

The whole of the upper country is well suited for cattle-raising during the summer, as the ground is covered with luxuriant grasses and other fodder plants, but the winters are long and hay for about four months must be made.

Timber available for house-building.

Though the greater part of the country has been burnt over, there is still an abundance of poplar and spruce for house-building and fencing purposes, and of course, for fire-wood, but there is no timber suitable for railway construction, except for ties.

In the vicinity of Vermilion, the climate is much better than in the upper Peace river region. This is due chiefly to the fact that the country is about 1,500 feet lower than the Grande Prairie and the district about Dunvegan. Wheat ripens here in about three years out of five and barley and oats are seldom touched by frost. The soil too is better suited for continued cultivation, for though somewhat lighter

than that described above, it is of great depth and very fertile. A large mill operated by the Hudson's Bay Company furnishes a market for wheat which is at present wanting in the upper country, the surplus flour ground at Vermilion being sent down the river for the northern trade.

A careful study of the vegetation was made during the season and upon that, some of my conclusions are based. Collections of plants, birds, insects and small mammals were made, which constitute a pretty complete representation of the flora and fauna of the region. Mr. Spreadborough, who has been with me for so many years, proved, as usual, an efficient assistant.

Conclusions based on study of vegetation.

From Lesser Slave lake I returned to Ottawa in the autumn by the route followed in going out in the spring.

On the Coal basins in the Rocky Mountains, Sheep creek and Cascade Troughs, northward to the Panther river.

D. B. Dowling.

Mr. Dowling devoted the early part of the year to writing a report on the coal deposits of the Souris river in Assiniboia. His field-work for the past summer was not commenced till the beginning of June. He writes: I left Ottawa June 3, calling at Winnipeg for Mr. Fred. C. Bell, my assistant for the season. As the horses to be used had been wintered on a ranch near Blairmore, we went to that place first. The rivers being all very high and many of the bridges gone, I found we would be obliged to send the horses north by the roads through the settlements, and cross the Old Man river at McLeod. Our point of departure with loaded pack train was Okotocks, a station on Sheep creek, on the McLeod branch of the Canadian Pacific Railway, twenty-six miles south of Calgary. A rough wagon road is built up this valley through the foot-hills to Mr. Lineham's lumber camp, just outside the first range of mountains. Pack trails, which we were able to follow, run from this point into the mountains.

Sheep creek.

Through the foot-hills the valley widens gradually to the east, and it appears to be pre-glacial. The present stream cuts through wide terraces and near the mountains it runs in a gorge excavated through shales. On the road, about five miles west of Okotocks, large erratic blocks of quartzite appear on the smooth surface and the absence of eastern drift is noted. Near Lineham P.O., coal has been mined for local use, from a seam exposed on the bank of the south branch of Sheep creek. Another outcrop was noticed in Tp. 19, R. 4, on the hillside west of Maccabee creek, which appears to be on the west

Coal seams in foothills.

side of an anticline, and may represent the same seam or coal horizon. The coal from this mine has been examined by Dr. Hoffmann, and as it proves to be a good quality of coking coal, Dr. Hoffmann's analysis and his remarks upon it are added here :

'Coal from the Sheep creek coal mines, south fork of Sheep creek, section 2, township 20, range 3, west of the fifth initial meridian, district of Alberta, North-west Territory. Seam said to average about four feet in thickness. Geological position, Cretaceous. Received from Mr. H. Gruner.

Analysis of coal.

'Structure, for the most part very fine, lamellar, with occasional interstratified, more or less disconnected, lenticular layers of dense, pitch-black, highly lustrous coal; compact; in parts shows traces of slickensides; hard and firm; does not soil the fingers; is, here and there, intersected by thin plates of calcite; colour, black; lustre, on the whole, resinous; fracture, uneven, occasionally more or less conchoidal; colour of powder, blackish brown; it communicates a very pale brownish-yellow colour to a boiling solution of caustic potash.

'A proximate analysis, by fast coking, gave :—

Hygroscopic water	3·08
Volatile combustible matter	39·37
Fixed carbon	54·50
Ash	3·05
	100·00
Coke, per cent	57·55

Ratio of volatile combustible matter to fixed carbon, 1 : 1·38.

'It yields by fast coking a firm compact coke. The gases evolved during coking burnt with a yellow, luminous, smoky flame. The ash has a brownish-yellow colour; exposed to a bright red heat it does not become agglutinated; at a most intense red heat it becomes more or less fritted.

Coking coal.

'Experiments have been made on a large scale in the preparation of coke from the above coal, employing a Coppée's coke oven, and with very encouraging results, the product being of excellent quality. The sample sent for examination has a steel-gray colour and bright lustre; is hard and dense and apparently capable of supporting a considerable pressure without crumbling and may be regarded as a most useful metallurgical fuel. It was found to contain : moisture, 0·17 per cent, ash, 10·70 per cent.'

Other seams, which I did not see, have since been reported by Mr. John Lineham as having been opened near the river in the canyon in Tp. 19, R. 5, nearer the mountains. These are of a much higher grade of coal and a sample from near Lineham's upper lumber camp, probably in section 19, said to have come from a ten feet seam, unfor-

tunately contains a large per cent of ash, but this may not hold good for the whole seam. It is otherwise an excellent fuel and may be classed with the anthracite coals. Dr. Hoffmann's analysis is as follows:—

An analysis by fast coking gave:—

Hygroscopic water	0·53
Volatile combustible matter	14·99
Fixed carbon	64·55
Ash (grayish white)	19·93
	100·00

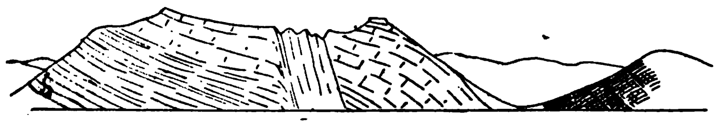
It yielded by slow coking, a non-coherent; by fast coking, a compact, firm, coherent coke.

Ratio of volatile combustible matter to fixed carbon, 1 : 4·31.

West of this, the beds all slope toward the mountains and the rocks seem to form an ascending series. Above the coal-bearing rocks there is a thick group of coarse sandstones with beds of conglomerate, followed by beds of dark, nearly black, shale. These rocks dip sharply to the west and cross the river in a band about a mile wide, at the eastern edge of Tp. 19, R. 5. They are followed by sandstones, perhaps 2,000 feet thick, and then by a gray shale which extends up the river through the canyon to a point beyond the lumber camp. These latter rocks appear very much like the Pièrre shales of the plains, and, as the foot-hills here are capped by a sandstone formation, it would seem that some of the Laramie rocks might be found near the foot of the mountains.

There is some local disturbance in the shales near the contact with the limestone of the Rocky mountains but they pass beneath the latter and the section here has the appearance of that given by Mr. McConnell for the gap on the Bow and Ghost rivers. That is, the limestone, after the great Rocky mountain uplift, has been shoved to the eastward over the cretaceous rocks. The limestone dips toward the west, but at the centre of the range there is a sharp dip down, so that they are nearly vertical, and then there is a break, the rocks on the west side being at first nearly horizontal and finally dipping under the cretaceous of the trough of the head waters of Sheep creek. The lower part of the outer face of the mountains is of a shaly limestone, probably Devonian or Silurian, capped by thick-bedded limestones of the Devono-Carboniferous. The sketch below will better illustrate this. First range of mountains.

The Cretaceous rocks exposed here are a continuation northward of the wide basin on the Highwood river behind the Livingstone range.



SECTION 1.

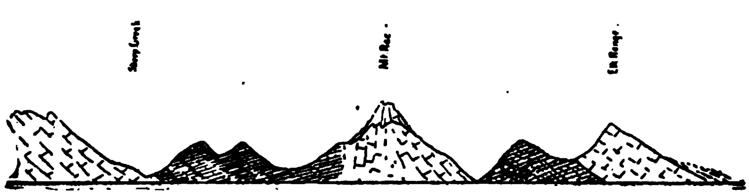
Through the first range from east to west.

Cretaceous area in mountains.

This, when followed north is mapped by Dr. Dawson as being divided into two distinct basins by the Misty range. In the southern part, it is probably a sharp anticlinal fold with a syncline of Cretaceous rocks on either hand, but northward towards the Elbow valley, several breaks occur in this fold and it loses its simple structure. Northward from the Elbow river the crown of the anticline is broken by faults and the western limb of the fold is shoved over the eastern and comes in contact with the Cretaceous. Another fault, west of the main one, brings up another block forming Tombstone mountain and several small areas of reddish rocks which look like remnants of the Cretaceous, but are of small extent. The valley in which the Elbow river flows owes its origin to a fault which runs east and west through the first range from the vicinity of Tombstone mountain and on either side of this it seems evident that there is a change in the structural form of the Cretaceous areas.

Sections through mountains.

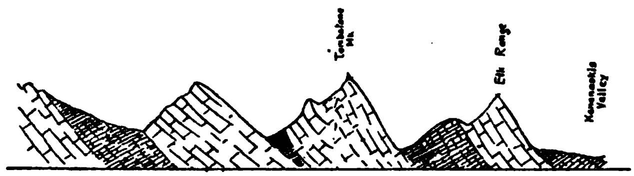
On Storm creek the structure probably changes in much the same way as on Sheep creek. On the stream flowing north towards the Kananaskis the beds are in a monoclinal ridge with the limestone of the Elk range overriding them. From the summit on the Elbow river a sharp synclinal fold is seen to develop toward the south and some folds in the Sheep creek area, about the centre, suggest the same formation. The diagram, Sec. 2, represents a sketch-section through these ranges looking from the north.



SECTION 2.

Sheep creek to the Kananaskis.

The fault-blocks north of the Elbow river, viewed from the north, would have somewhat the appearance suggested in the next figure.



SECTION 3.

North of Elbow river.

In the above diagrams the Cretaceous rocks are shaded darker than the limestone.

The coal seam that has been opened up is perhaps the lowest in the series. It is on the south-western side of the valley and near the eastern edge of the Cretaceous. The pack-trail that comes over the summit from Mist creek follows along the north side of a ravine running down to Sheep creek and in the bed of this stream float coal was discovered and traced up to the seam.

Anthracitic coal.

A short tunnel was put in on what proved to be a seam of about nine feet in thickness. It dips 50° to the S. W. The lower part measures six feet of bright coal, but the upper part is very much crushed and falls to dust. This character, however, is found to vary very much in the mines to the north, and crushed portions of the seams are expected. An analysis of samples from the tunnel was made by Dr. Hoffmann and shows the coal to be lower in fixed carbon than true anthracite. Dr. Hoffmann's analysis is appended.

'MEMO.—*Re* sample of fuel from a seam on the south branch of Sheep creek, section 11, township 17, range 7 west of the 5th initial meridian, district of Alberta, N.W.T., collected by Mr. D. B. Dowling, 1903.

The sample of the fuel, a semi-anthracite (in common parlance, anthracite), examined, gave, by fast coking, as follows :

Hygroscopic water	1.30
Volatile combustible matter	11.14
Fixed carbon	77.13
Ash, white	10 43
	100·00
Coke, non-coherent	87.56

Ratio of volatile combustible matter to fixed carbon, 1 : 6·92.

Cascade Coal Basin.

Cascade coal basin on Bow river.

The continuation of the Sheep creek coal areas northward is supposed to join the coal measures which cross the Kananaskis and to form part of the Cascade trough. The connection was not traced up this summer, but the Cretaceous probably occurs high up in the ranges. South of the Bow river the Cretaceous rocks are in an elevated plateau, partly dissected into ridges running east and west from the limestone which is pushed up against it on the west. This has been brought up by a combination of sharp folds along a line of weakness, at which faulting has also taken place. The amount of throw has not been sufficient to allow of an overlap of the limestone upon the Cretaceous, as in the sections north of the Elbow river. The west-to-east displacement has been taken up, however, by folding and in the hills south of The Gap, by a bending-up of the Cretaceous beds as well. The synclinal form which was accepted by Dr. Dawson as being the structure for the whole trough is true for the extreme ends only, or for the southern part and that north of the Cascade mountain, which will be mentioned further on. For a long distance north from The Gap the bend in the beds is not part of a complete fold. The sketch here reproduced is intended to illustrate roughly that part of the basin extending from the bend in the Cascade river at Cascade mountain, southward to the Cretaceous plateau near the Kananaskis.

Sketch of Cascade Coal Basin looking South from Cascade Mountain.

Folding in mountains.

The beds to the south are seen to be nearly horizontal, but near the fault-contact they are bent or brushed up. Between The Gap and Canmore, most of the folding has taken place in the limestone, so that less displacement was necessary in the Cretaceous. From the Three Sisters mountain just south of Canmore, to the north end of Rundle mountain, the folding in the limestone on the west side of the fault is in sharp, almost vertical, waves and indicates a greater east and west displacement and probably greater pressure. The effect on the Cretaceous rocks is a steepening of the slope at which they dip and also a

series of foldings which run diagonally along the bedding planes downward towards the south. The southern limit of the area in which these folds are developed and the dip increased is defined by a line running from the edge of the Bow river, a mile below the Canmore mine, to the base of the slope at the Three Sisters.

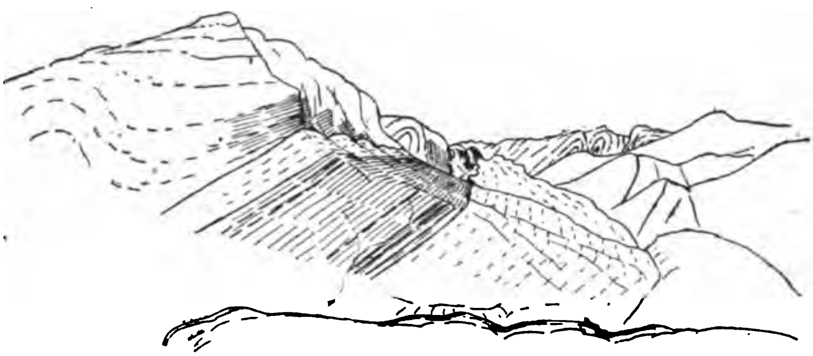
Mining operations prove that the coal often pinches out along the line of the minor folds, where they have become flattened by the pressure. The bends in the seams near the eastern edge of this area are in longer waves and form saddles and troughs which are mined out in the general operations, the coal being merely more crushed or the seam thinner. At the Canmore mines a tunnel, which is being put in at a mile south of the town, runs in on an almost horizontal seam; but this is found to turn up sharply to the vertical and come to the surface. To the west of this, the beds are again dipping down and some of the seams in the mine may represent a return downward of the western part of this wave.

From Canmore to Anthracite there are no exposures of coal, but it would seem that the Cretaceous rocks form a continuous series, as the succession of beds in both places is similar and the dip about the same. There is, however, a change in conditions that has an important bearing on the character of the coal. An extra pressure has been induced in a part enclosed within a fold which runs at an easy slope downward to the south from a point north of the mine. A change in the general strike of the beds is also inaugurated here, and the cause of this fold is connected in some way with this bending of the plane and also with the fact that here is the point of maximum downthrow.

Anthracite in a fold of the beds.

The mining operations have been confined to the inner side of this fold and it is probable that the coal, when followed south along the strike, may after the fold is passed, return to the character of that at Canmore.

The denudation of the valley by the Bow river has removed a great thickness of strata below the bed of the stream and it seems impossible to follow the fold in the southern part of the mine; but to the north, where the trough is shallow, prospecting shafts show a bending of the upper part of the western side to the west, thus indicating a tendency to turn down again. As this point is some distance from the Cascade river, there appears to be a good chance of finding all the seams again and tracing them northward to the banks of the stream where the first mining was done. The anthracitic character would in this part probably be lessened.



Sketch of Cascade Mountain Coal Area.

Cascade coal basin north of Bow river.

Northward from the bend in the Cascade river, the limestone series is pushed up along a fairly straight line of break, which seems to have followed very near the plane of bedding of the upper part of the Cretaceous. The Devonian beds have been brought up to an elevation of about 7,000 feet in the eastern face of Cascade mountain, but they become gradually lower along the contact toward the north. A block of six or eight miles of the coal-bearing rocks remains in the slope of the mountain, but north of this there is a return to the trough form, as at the southern end on Mist creek, and the fold in the mountain to the west is quite plain. The coal rocks are in this part all denuded away.

Coal on eastern face of Cascade mountain.

In the gorges on the face of the Cascade range, the outcrops of the coal seams have been prospected by Mr. J. C. Gwillim for the Canadian Pacific Railway Company and as many as fourteen seams were found in the coal measures which comprise about 2,000 feet of beds. Many are small but several will be thick enough to work and tunnels are now being run in on these seams from the face of the hill at the south end, near the base of Cascade mountain. None of the seams may be expected to be free from crushing and the local folding, but the southern part will probably be the best. In the gorges, several sections across the measures were obtained and these all show more or less folding. Toward the northern part of the block, a wide syncline is developed and this probably passes into the complete fold. A break, however, occurs across the range and the trough to the north has been bent into a much sharper fold and the coal-bearing beds, which would be in the centre of the trough, are denuded.

In the sketch above, it is endeavored to show roughly the attitude of the beds and the fold which forms a continuation of the Cascade

range. This, after approaching the eastern side and narrowing the valley so that there is but a ribbon of Cretaceous left, sinks beneath a wider basin of these rocks, extending north and west to the Sawback range. In this there is very little depth of Cretaceous rocks remaining, and only the tops of some of the hills in the centre contain the coal measures. Two distinct lines of anticlinal folds run northward through the field and the character of the contact of the Cretaceous rocks and the lower ones on the west side of the field depends on the position of the underlying ridges. On the south side of the Panther river, the Cretaceous barely comes in contact with the lower rocks at the Sawback fault, as they are denuded from the top of an anticline, just east of this fault. This anticlinal ridge runs beneath the field south-eastward and is probably the one suggested in the western part of Cascade mountain, as shown in the last sketch.

The explorations, of which the results are outlined above, were plotted in the field on the topographic map made by the Department of the Interior and thus surveying operations were restricted to measuring sections on the streams and wherever exposures occurred.

I am indebted to Mr. O. E. Whiteside for information relative to the Canmore and Anthracite mines and to Messrs. J. C. Gwillim and H. H. Aldridge of the Canadian Pacific Railway for information relative to their operations on the Cascade measures. Acknowledgements due.

After closing the field-work for the season and placing the horses on a ranch for the winter, I proceeded east, stopping at Regina for a short time to obtain from the local government records of wells bored in the south-eastern part of Assiniboia.

Geology of the International Boundary.

Dr. R. A. Daly.

During the past season I continued the geological survey of the ten-mile belt adjacent to the forty-ninth parallel of latitude on the Canadian side of that line. The section covered is continuous with the section mapped in 1902 and lies between the Salmon river in West Kootenay and the western boundary crossing of the Kootenay river. The area surveyed in detail in 1903 covers about 350 square miles. The total length of the ten-mile belt to be thus surveyed on the Canadian side of the boundary line between the Great Plains and the Pacific is 450 miles. Records on the more or less detailed geology of just half that distance are now in hand. Area covered.

I left Ottawa on July 17 and returned in the middle of October. In accordance with the arrangement of last year I was attached to the camp of Mr. W. F. O'Hara, D.L.S., to whom was intrusted the work of cutting the boundary slash along the southern limit of the belt over which my investigations extended. Owing to the configuration of the country, however, it was found impossible to carry on the geological work necessary to the development of the east and west structural sections if I remained in Mr. O'Hara's camp. I therefore hired a packer and special pack-train of four horses for about six weeks. With this small outfit I was enabled to travel rapidly and with a much greater thoroughness in exploration, with also a greater economy of time and therefore of expense to the government, than if the services of the main pack-train had been called upon for transportation as in the two previous years.

Throughout the season I was ably assisted by Mr. A. G. Lang, of Waneta, B.C., who left nothing to be desired in the efficiency and helpfulness of his work,

General Topography.

The belt of country studied lies entirely within the southern Selkirk mountain system and bears the most rugged topography to be found in the whole 250-mile stretch along the 49th parallel between the Cascades and the main range of the Rocky mountains. The strength of the relief is conditioned by the comparatively low altitude of the master valleys of the region and by the number and considerable elevation of the mountain summits. The floor of the broad Kootenay river valley is 1,750 feet above the sea; that of the Salmon river valley, 2,100 feet above the same datum. At least twenty distinct peaks in the belt are over 7,000 feet in altitude; for the highest 7,590 feet has been measured. These higher summits belong to the "Quartzite Range", a local member of the Selkirk system and the sierra dividing the drainage of the Columbia and Kootenay rivers.

Three groups of branching canyons occur on each slope of the range. The east-flowing Boundary creek, Corn creek and Summit creek with their respective branches occupy the canyons of the Kootenay versant. Sheep creek, Lost creek and the South fork of the Salmon drain the no less imposing trenches on the western side of the main divide. A seventh canyon system is drained by the head-waters of Priest river, flowing south in the middle of the belt. Except on the flood-plain of the Kootenay, the country below the 6000-foot contour is heavily forested and is further made difficult of access, especially where the trees begin to thin out at the higher levels, by a dense growth of rhododendron, alder and other "brush". It was therefore gratifying

to find that each of the main valleys excepting that of Corn creek carries a more or less passable trail. The old government (Dewdney) trail for sixteen miles up Summit creek canyon has been put into good condition by the Bayonne Mining Company. The Boundary creek trail has been similarly cleared nearly to Boundary lake by the Continental Mining Company, operating south of the boundary line, and was this summer partly replaced by a wagon-road. From the lake the trail was continued by Mr. O'Hara's party over the divide to the South fork of the Salmon. It is to be regretted that the Dewdney trail is not kept open throughout, as a means of communication between the Kootenay and Columbia valleys, thereby, too, permitting of a more thorough prospecting of the range than has yet been accomplished. As usual the geological traverses were largely confined to the ridge-summits, where alone large exposures of rock can generally be found. For this reason our camps were kept at altitudes greater than 4000 feet above sea during most of the season.

Scenery.

The scenery of the belt is that characteristic of alpine mountains, already imposing at the Kootnay river, but becoming more and more wild, in places even savage in its ruggedness, as the line of divide is approached. Looking from any of the higher summits, sharply pointed "horns" dominating rocky razor-back ridges, high precipices flanked with long screes or slopes of rock-débris fallen from the cliffs, steep canyon-walls reaching their thousands of feet down to the torrential streams slowly deepening their valleys, made the foreground. Across the tumbling mountain-sea the yet loftier, glacier-covered masses of the Valkyr and Valhalla ranges in the northwest, the Slocan mountains in the north, the Alps of the Purcell range in the northeast, and the wonderfully ragged granitic piles of Idaho to the southeast and south, made a type of scenery in most welcome contrast to the less extended views obtained last season from the lower, forest-covered domes and rolling ridgeland west of the Salmon river.

Glaciation of southern Selkirks.

True glaciers are wanting in the belt, and the patches of old snow in ravines and on the shaded northerly slopes are small and unimportant. The region abounds, however, in evidences of former heavy glaciation. Observations made last season on the 125-mile boundary belt across the Gold ranges and "Interior Plateau" corroborated Dawson's conclusion that an immense south-flowing ice-cap of the last glacial period submerged all but a very few high mountain-summits in the broad central zone of the British Columbia Cordillera. The maximum height at which signs of that glaciation may be found immediately west of the quartzite range, was proved to be about 6,400 feet. It was accordingly a matter of surprise and interest to find that the

same limit just east of the divide on the same range unmistakably reaches to 7,200 feet above sea level. It seems highly probable that this difference of level is to be explained by a more pronounced accumulation of ice on the eastern versant of these Selkirks than by a late warping of the earth's crust once covered by the ice-cap to a uniform contour. The striae on summits of 7000 feet trend to the south south-east, showing that the upper layers of the ice were practically unaffected in direction of flow by the adjacent deep, east-and-west canyons. The ledges in the canyon bottoms, are grooved and striated down-stream apparently by the late glacial ice-streams joining the great trunk glaciers of the Columbia and Kootenay valleys. The net result of glaciation in the belt has been to remove the pre-glacial veneer of weathered rock, to polish and score the fresh rock beneath, and to remove the débris from the country. In consequence, comparatively little drift covers the mountain slopes or canyon bottoms.

Lack of fossils.

In accordance with the programme of work adhered to during the two previous seasons, nearly all the time in the field was devoted to the problems relating to the distribution, structure and history of the bed-rock terranes. Again this study was seriously affected by a truly amazing rarity of organic remains. To anyone acquainted with the geological litterature of British Columbia, such remains must appear of the very first importance. Much has been written concerning the lithological and stratigraphical characters of British Columbia formations, but the final correlation of the latter has been delayed in an extraordinary way on account of the generally unfossiliferous nature of the stratified rocks. The search for fossils has, therefore, been pursued with special care wherever sedimentary formations have been met with in the boundary belt. Such rocks were found this season in unusual thickness and in splendid exposure; yet not a single fossil species useful for geological correlation was discovered. The experience agrees with that of Dawson, McEvoy, Brock, McConnell and other geologists working west of the Rocky mountains proper, in disclosing a marvellous barrenness of fossil remains in the Canadian Cordillera, which therein, seems to stand in contrast with, for example, the Appalachian mountain system of Eastern America.

On lithological grounds the formations found this summer are perhaps to be correlated best of all with those of Dawson's Selkirk section made along the line of the Canadian Pacific Railway and about 150 miles to the north-northwestward. His section includes the Shuswap (Archean), Nisconlith and Selkirk Series (Cambrian and Cambro-Silurian). Yet it is still too soon to make the correlation final and, indeed, I consider it safest in this brief preliminary notice of field work not to

attempt any but the most general statement of formational divisions in the area studied; in like manner, the questions of geological equivalents must be left open until the rock collections have been systematically studied and the formation limits accurately plotted on the topographic maps.

Compensating interest in the geological examination was, however, found in the local structural relationships of the formation. Probably nowhere in the 300-mile stretch along the 49th parallel from Kootenay lake to the western slope of the Cascade range are the conditions so favourable for a lithological and stratigraphical study of the sedimentary rocks which are among those that may be called staple in the British Columbia Cordillera. Fovorable conditions for structural and lithological study.

With the exception of a narrow belt along the western wall of the Kootenay valley trough, the eastern half of the belt covered in 1903, is underlain by a great series of crystalline schists—biotite schist, sericite schist, phyllite, quartzite and quartz-schist, with many bands of yellowish-weathering silicious marbles—cut by thick sills and dikes of dioritic rock, metamorphosed into an amphibolitic condition and by a batholith of coarse porphyritic granite which crosses the boundary from Idaho and forms the ridge of Rykert mountain at the western slope of the Kootenay valley trough. The western half of the belt is for the most part underlain by a younger conformable group of formations, including thick bands of coarse conglomerate, arkoses, volcanic breccias and flows, quartzites, sandstones and slates with rare, thin intercalations of fine-grained crystalline limestone. The two series are separated by an unconformable contact running northward from a point half a mile west of Priest river. This unconformity signifies an enormous break in the physical history of the region and is one of its principal features of structure. The older rocks east of the contact had already been folded into complex, lofty mountains and then greatly wasted down by secular erosion before the lowest and oldest member of the group west of the contact had been formed. Since the required sections have not yet been plotted, a statement as to the respective strength of the various rock-bands cannot be given, but it is known that the western series must total at least 30,000 feet in thickness. Geological formations. Great unconformity.

Both series were powerfully affected by that mountain-building force to which the Selkirk range owes its existence. Pressure was applied from the eastward with such intensity that the stratified rocks of the entire area were tilted up and for the most part overthrown so that the dip of the beds now ranges from 70° to 85° to the east. The structure is thus essentially monoclinal and on the first approach,

suggests that the formations met with are successively older as one crosses the belt from east to west. That the true order is just the reverse was first suggested by the finding of the great unconformity. It was finally proved by the orientation of repeatedly discovered and excellently preserved ripple-marks in the quartzites and sandstones of the Quartzite range.

Thrust-faults. While the generally monoclinal attitude characterizes the sedimentaries west of the great unconformity, the structure is complicated by the dislocations due to three master-faults. Two of these run transverse to the (meridional) strike and represent nearly vertical thrust-planes separating three great blocks, into which the monoclinal mass has been divided during the energetic mountain building. The middle block has been displaced half a mile to the westward with reference to the northern block which lies north of Summit creek canyon. The southern block has been thrust three-fourths of a mile to westward with reference to the middle block, the thrust-plane in this case crossing the boundary line at a low angle.

Rotated thrust-fault. The third thrust-fault crosses the Dewdney trail in Lost Creek canyon at a point three miles in an air line from the summit of the Quartzite range. It lies in the plane of bedding and thus belongs to a different category of dislocation. In the process of lifting the mountains, the quartzitic formation was fractured on a weak zone. The thick block of slates, sandstones and quartzites overlying that zone was driven bodily over the back of the block lying to the eastward, giving a normal overthrust. Either simultaneously with that movement or, as is less likely, immediately following it, both blocks were so rotated about a north-and-south subterranean axis that both strata and thrust plane were overthrown into a position now giving a high easterly dip for both the plane and the bedding. In this way there has been produced a duplication of about 10,000 feet of strata on the western side of the divide—a duplication that goes far to explain the great width (about seven miles) of the quartzitic zone composing this part of the Selkirk range. That there is no other important duplication and that the breadth of the zone is due to the immense thickness of the steeply inclined, monoclinal strata, can be unquestionably affirmed. Three different east-and-west structure sections on ridges giving excellent, often even spectacular rock-exposures, agreed in affording an undoubted conclusion as to the structure. Each rock-band has its own peculiar petographical character and relations, so that duplication either by faulting or folding could be easily recognized. With the exception noted the formations become successively younger

in passing from the Priest river unconformity to the western limit of the section of the boundary belt covered this season.

Origin of the Kootenay valley.

The great valley of the Kootenay river is, within the ten-mile belt, underlain by an unfossiliferous rock-series which has lithological characters differentiating it from all the rock-terranes to the westward. This series is largely composed of gray, heavily bedded quartzites with thin micaceous partings. It forms the western extension of the so-called "Cambrian" Quartzite formation which, according to McEvoy, covers most of the district of East Kootenay. The quartzite has been faulted down against the much older crystalline mass just noted in the (eastern) part of the belt situated between Priest river and Rykert mountain. West of the Kootenay flats, the dip of the quartzite averages about 60° to the southeast; east of the river the same formation reappears from beneath the river alluvium with an average dip of 10° to the east. This sharp discordance of attitude is well marked for the whole ten miles along the valley between the boundary line and Creston junction, and points to the fact that the Kootenay valley is located on a principal zone of fracture-displacement. McConnell has found similar evidence on the shores of Kootenay lake. The valley owes its origin either directly to the subsidence of a long narrow block of the mountain-built crust of the earth (then a fault-trough or "graben") or, as is more probable, it is the result of river-excavation on a zone of rock rendered weak by the shattering and faulting. In comparatively recent geological time, the normal river-profile of the valley was altered and Kootenay lake came into existence. At one time it extended with its full width of from two to four miles far to the southward of the boundary line. The fifty square miles of alluvial flats and sloughs between the line and the outlet of the river is a true delta-area. The river is still building up its flood-plain which forms some of the richest arable land in British Columbia.

Granite stocks and batholith.

Either at the closing stage of the paroxysmal uptilting of these mountain-built strata or in still later geological time, the base of the range was punctured by four considerable bodies of granite. Two of these, as exposed by denudation, are located wholly within the ten-mile belt and occur on the main divide close to the Dewdney trail. Their combined areas total only about three square miles. The third body, with an area of seven square miles, is exposed on the floor and walls of Lost creek canyon as well as on the ridge to the northward. The fourth is much the largest of the bodies, covering at least 100 square miles in the lofty mountain region north of Summit creek. Only the southern edge of this great "batholith" enters the ten-mile belt. In the case of every one of these bodies the superficial extent of the visible granite is

less than its subterranean horizontal extent. In several instances it can be shown that the area exposed is in direct relation to the depth of canyon-cutting which has laid bare the once deep-seated granites.

The Lost creek granite body bears the look of an enormously enlarged east-and-west dyke whose intrusion was affected by the previous existence of an east-and-west joint system traversing the tilted sedimentaries. The eastern limit of this granite is located at the great meridional thrust-fault above mentioned. It seems probable that the intrusion is also in organic relationship to the hoisting of the block on the west side of the plane of thrust.

Mode of intrusion.

The other three intrusions have, in the main, no discoverable connection with either zones of faulting or joint-systems, or any axes of general deformation whatsoever in the older formations. The numerous radiating apophyses do often follow pre-existing joint-planes in the schists or sedimentary rocks, but neither the horizontal plan nor the vertical profile of the granite body as a whole is in any case determined by structural planes in the invaded formations. These granites, like a score of intrusive stocks and batholiths encountered to the westward in the boundary belt, seem unquestionably to have eaten their way upward into the stratified and schistose formations which have thus been extensively displaced by the granite magma itself. How the displacement took place is a problem of first-class importance as it bears directly on the origin of the igneous rocks of the whole Cordillera. A general discussion of the various possibilities in the way of explanation was published this year in the April and August numbers of the American Journal of Science. The conclusion was that the process of intrusion in such cases is primarily mechanical, consisting in a combination of the contact-shattering of the invaded rocks with the "overhead stoping" of the shattered rocks. The experience of the past season has tended greatly to strengthen my belief in the hypothesis. The collars of shattered rock wrapping around the intrusive bodies vary from a quarter of a mile to nearly two miles in width. The contact metamorphism of the schists, slates and sandstones within the collar is quite extraordinary in the degree of alteration suffered by those rocks. The intensity of the action and the clearness of proof that the metamorphism is to be attributed to the influence of the intrusive magma, are impressive in the highest degree.

Gold and silver bearing quartz veins.

During the period of mountain-building and later, during the intrusion of the granites, the bedded rocks in all parts of the belt were extensively jointed and broken. The resulting fissures have been filled with quartz, often bearing traces or notable quan-

tities of auriferous and argentiferous sulphides. The veins have specially great width and length in the Quartzite range. A large number of these veins were sampled and studied. On account of the present lack of assays and of other preliminary aids to description, it is yet too early to present a report on the economic probabilities of the quartz bodies. A fair amount of prospecting has been carried on in the belt but without such success so far as to warrant extensive mining development at any point. As usual elsewhere in British Columbia, only a negative interest has for the most part been taken by prospectors in the discoveries of low-grade auriferous veins, their attention being perforce devoted almost exclusively to the problem of finding concentrated values. This season's experience accords with that of last year in pointing to the advisability of further prospecting in the belt for low-grade gold deposits among the larger quartz veins. It also seems clear that free-milling gold is not to be expected in the vast majority of the veins. The common sulphides, chalcopyrite, pyrite, chalcocite, and galena with their decomposition products bear the precious metals. The three last mentioned sulphides occur in small pockets or bunches in the bands of silicious marble on the head-waters of Priest river. For some years the mineral claims of the "Copper Camp" located on the strike of this zone of crystalline lime-stone, have been much talked about by sanguine prospectors, but the showings everywhere in the "camp" are so poor that further development on the claims seems most unlikely to pay.

Gold-quartz of the Bayonne Company.

A much brighter outlook belongs to a gold-quartz claim now being worked by the Bayonne Mining Company. The property is located on the extreme northern limit of the ten-mile belt, about five miles up the West Fork of Summit creek and at an altitude of about 6,900 feet above the sea. The lead consists of a three to six feet quartz vein following a weak zone in the granite batholith. The vein occurs about two miles from the nearest contact of the granite with the schists. For a width of from one to twelve feet on each side of the vein, the granite is thoroughly kaolinized and it is much decomposed outside the zones of kaolin. The ore-dump contains the greatly oxidized quartz-bearing small grains of free gold, along with chalcopyrite, galena, pyrite, malachite, azurite, limonite and quartz druses. A 300 feet tunnel and a fifty feet winze represent the state of development at the present time. It is stated that the quartz gives $250 to the ton as the result of averaging six assays. It is also claimed that both the kaolin and the decomposed granite may be profitably worked. The abundant sulphides in the dump indicate, however, that the ore will not prove free-milling in depth. The mine has good water-power

available in the vicinity. This quartz occurrence is especially interesting, as gold-bearing veins in granite are very rare throughout the boundary belt so far examined.

Occurrence of magnetite.

A deposit of magnetic iron ore aggregating eight feet in thickness, though interrupted by small lenses of quartzite, was noted in the structure section carried along the ridge overlooking the South Fork of the Salmon river just north of the boundary line. The deposit is interbedded with the slates and quartzites in the upper part of the great stratified series forming the main mountain range. The bed is noteworthy because of the apparent purity of the ore and on account of its mode of occurrence which suggests persistence of the ore-body along the (meridional) strike. It was found in its proper place in the stratigraphic series, though with greatly reduced thickness, as a similar cross-section was made on the ridge north of Lost Creek and seven miles north of the former section.

The Winisk River, Keewatin District.

Mr. William McInnes.

Country explored.

Mr. McInnes left Ottawa on May 22, for the purpose of making a geological examination and survey of the Winisk river, which flows into the west side of Hudson bay about a hundred miles east of the Severn, in the District of Keewatin. As it was necessary to carry supplies for the whole summer, the route from Dinorwic station, on the Canadian Pacific Railway west of Lake Superior, was chosen as the easiest and quickest for loaded canoes. This route has been described in considerable detail by Dr. Bell in his report for the year 1886, and by other explorers, so that it will be necessary to refer to it only briefly here. Following Lake Minnitaki and the English river to Lac Seul, the latter lake is ascended north-easterly to its head and the Root river and one of its tributaries from the east are followed to the height of land between the waters flowing westerly by the English river into Lake Winnipeg and those flowing directly into James bay by the Albany river. While descending St. Joseph or Osnaburgh lake on June 13 the swamps adjoining the lake were found only partially thawed out and the minimum thermometer recorded 22° Fahr. on the night of the 12th, the maximum reaching 64° during the day and rising to 72° on the 15th.

Route followed.

Lake St. Joseph.

Osnaburgh House.

At Osnaburgh post, near the foot of the lake, with an elevation of about 1,200 feet above the sea, Mr. Williams, the Hudson's Bay Com-

pany's agent, maintains a small garden. Owing to the sandy nature of the soil in the neighbourhood of the post, the best results could not be expected. Mr. Williams informed me, however, that barley ripened well and that potatoes, peas, beans, carrots and large onions were successfully grown, but that Indian corn was hardly filled out sufficiently for table use when struck by the frost. Timothy was a splendid crop.

From the foot of Lake St. Joseph the Albany river was followed for about 125 miles to Fort Hope, a post of the Hudson's Bay Company situated at Eabemet lake, which lies just to the north of the Albany and discharges into it. The river for this part of its course is a succession of alternating lake-like expansions and stretches of rough rapids, some of the latter passible only by portaging. Brook trout (*Salmo fontinalis*), from three to four pounds in weight, were caught plentifully in these rapids and sturgeon of good size are taken by the Indians all along. About Fort Hope post on Eabemet lake the soil is very sandy and not well adapted for horticulture. Mr. Gordon, the postmaster has, however, successfully grown all the common garden vegetables, including vegetable marrow and potatoes, though Indian corn failed to fill out. For the past two years grasshoppers have devoured almost everything green in the garden. These locusts, which Mr. E. M. Walker has identified as *Melanoplus birittatus* and *M. femoratus* (Say) Burm., were found also in great numbers in open places about Weibikwei lake in latitude 52° 15′ N.

Albany river.

Brook trout.

Fort Hope.

Locusts.

The Indians do no farming and the only cultivated land seen was in the immediate vicinity of Fort Hope post, where, in addition to the company's plots, Rev. Mr. Richards, Anglican missionary, cultivates a small garden. Lumber for building was being whipsawed into deals measuring 12″ by 2″ by 20 feet, from white spruce that grows plentifully about the lake.

Horticulture.

In order to reach the Winisk river, the route northwards from Eabemet lake, taken by Dr. Bell on his trip to the Attawapiskat river in 1886, was followed. At Machawaian lake, Dr. Bell's course was left and the more direct route, missed by him, and leading directly to Lansdowne or Attawapiskat lake was taken. Ascending a small stream flowing into the western bay of Machawaian lake and crossing two small lakes, the route leads over the divide between the Attawapiskat and Albany rivers by a portage 74 chains in length, traversing a muskeg or swamp with occasional ridges of transported gravel and boulders. Manitush (leech) lake, at the north end of the portage, is two miles long and discharges southerly by a small stream, barely

Route to Attawapiskat lake.

navigable by canoes, into Martin-drinking river. Four portages are made on this stream before reaching Wintawanan lake, into the south-west bay of which Mud river flows from the west. A well travelled Indian canoe-route leads up this stream by a series of large lakes to the head waters of the Attawapiskat river and to the foot of Lake St. Joseph. The Martin-drinking river though not large, is navigable by canoes (with a few portages) to its mouth in one of the southern bays of Lansdowne lake.

Character of country.

The country traversed between the Albany and the Attawapiskat is a high, rolling plain, rising in the centre about 1,000 feet above the sea and sloping gradually to the north and south. It is characterized by large areas of muskeg, out of which rise low ridges of gneiss and also of sand and gravel. West of Machawaian lake a much higher and more broken country is seen. This, the Indians say, extends westerly, parallel with the upper course of the Albany, for a considerable distance, is well drained and has high hills and larger timber.

Route to Winisk river.

From the north-easterly bay of Attawapiskat lake, a small tributary brook, with three small lakes along its course, was ascended to the divide, across which a portage leads to the head waters of the Wabitotem river, flowing into Weibikwei lake on the Winisk river. For 13 miles north of Attawapiskat lake no exposures of rock *in situ* were seen, the country being, for the most part, covered by sand and gravel, rising in ridges 80 to 100 feet above the level of the lakes, and with smaller areas of muskeg between. A ridge of slightly schistose, hard, chloritic diorite, specked with iron pyrites and striking east and west, is the first rock seen *in situ*. As the last exposure of biotite-gneiss seen was on Attawapiskat lake, 20 miles to the south, and the first to the north occurs on Mistassin lake, six miles to the north, the Huronian belt may be of any width within the limits thus set. Between Mistassin and Weibikwei lakes the gneiss has generally a stratiform character and lies at low angles, often nearly horizontal, the typical rock being a rather hard, red, banded, biotite-gneiss, cut by a coarse white pegmatite-like rock.

Huronian belt.

Forest growth.

The dryer parts along this route have everywhere been burned over and are now covered with a second growth of Banksian pine, white birch, poplar, spruce and tamarack. The two last mentioned occur exclusively in the muskeg areas.

Weibikwei lake.

The distance from Fort Hope to the head of the Attawapiskat lake, by the course followed, is about 70 miles, and thence to the foot of Weibikwei lake is about 65 miles. Weibikwei lake has an extreme length of seventeen miles and is eleven miles wide. Nowhere in its

whole area, however, is there a large expanse of open water, as it is made up of several north and south channels, usually not more than half a mile wide, and about 30 feet deep, lying between long low islands of drift. The land about the lake is depressed and the islands merely low ridges of sand, gravel and boulders lying on a substratum of boulder clay.

Forest fires have swept the main land excepting in a few places, where spruces remain. Many of these are 12 inches in diameter with trunks of 30 feet clear of branches. Tamaracks and Banksian pines of good size are found in the unburnt areas and cedars of small size fringe the shore. Sturgeon and whitefish are caught in considerable numbers by the Indians, together with speckled trout, doré (or pickerel), and pike. No gray trout occur in the lake. Timber. Fish.

The Winisk river passes through the northern end of the lake, flowing into the north-west bay and discharging from the extreme north end. Just below the first rapid a channel that diverges from the river about 15 miles above the lake, rejoins it. This channel carries more than half the water of the united stream. The last white cedars were seen at the north end of the lake, and the last Banksian pine about half way down its western side, and some distance to the south of the lake the last black birch*, mountain ash or rowan, and mountain maple were passed. Winisk river. Northern limit of Banksian pine, &c.

The Winisk, for the first eight miles below Weibikwei lake, flows in a succession of rapids over flat-lying ledges of biotite gneiss. The Winiskisis (Little Winisk) leaves the main river at this point and flows off towards the north-east to rejoin it seventy miles below, forming an island of that length and fifteen or more miles in width. Thirteen miles below the head of this island, another channel, the Tabasokwia, splits off on the western side and flows around an island about twenty-three miles long by twelve or more in width. Gneiss. Branches.

The descent of the river for the upper 45 miles of its course below the lake is about 7 feet to the mile, with a vertical fall at only one place near the foot, where the Boskineig (smoky) fall has a sheer drop of about 15 feet. Exposures of biotite granite-gneiss, striking north-westerly, occur frequently all along this part of the river. Slope of river.

The country on both sides of the stream is low and flat, the immediate banks rising only a few feet above the surface of the water and gradually ascending to a general level not more than 50 feet above the bed of the river. The brulé of Weibikwei lake continues and the trees on both sides are a second growth of about 30 years. Nature of country.

* Mr. McInnes examined this tree carefully and considers it identical with the black birch of central Ontario, *Betula lenta*, although this region is far north of any other locality where it is known to occur.

Glaciation. The low bosses of gneiss are all well glaciated in a general direction varying from south to south-west, with here and there, striæ that are probably later, having a direction of about south-east. Below Boshkeneig fall, the banks become higher, the river flowing in a channel 8 to 10 chains wide between nearly vertical banks of till or boulder-clay. The first pleistocene marine clays containing fossil shells (*Saxicava* Marine clays. *rugosa*) were found at this point, though stratified clays of similar character were noted for about 10 miles further south. The elevation is estimated to be about 350 feet above the sea.

Last gneisses. Occasional outcrops of gneiss are seen at intervals for 15 miles further, below which point there are no exposures until the limestones of the Hudson bay basin are reached, 140 miles below.

Till. At no place in this distance has the bed of the river been worn down to the solid rock, the great mass of boulders washed out from the thick mantle of till probably affording the necessary protection.

Green forest. The old brulé, noted above, extends only to the last ridge of gneiss. The character of the banks and of the neighbouring country is very uniform. The banks consist of an exceedingly tough, impervious boulder-clay that holds up the water and creates behind the narrow belts of trees along the immediate banks (that are drained into the river valley) a great, level plateau-like country, practically without drainage and consequently moss-covered to a great depth, and supporting a stunted and deformed growth of black spruce and tamarack.

Tributaries. Tabasokwia branch rejoins the main river from the west 68 miles below Weibikwei lake and the Winiskisis from the east, at 77 miles. The first tributaries of importance are the Asheweigkaiegen and the Atikameig, flowing from the south-west and south-east respectively, into an island-studded expansion about a mile wide, 94 miles from the lake. The former of these, which is slightly the larger, the West Winisk of the maps, is one chain wide and from 2 to 5 feet deep, with a moderate current of about 2 miles an hour.

Last birches and balsams. The last balsam firs were seen here and the last white birches 10 miles down. The average width of the river is now about a quarter of a mile and the banks rise about 45 feet above it; the country extending far to the east and west of the stream is a flat, moss-covered plateau with small spruces and tamaracks scattered upon its surface.

Brooks. At 126 miles the river, which to this point, with a slight bend easterly, and then westerly, has kept a northerly trend, turns off abruptly to the east and keeps that course, inclining slightly to the south for 70 miles. Near the elbow, two large brooks come in from the west, the

Panipatowanga and the Pikwakwud. By the lower stream there is a canoe route to the Fawn branch of the Severn river. Twenty miles further on, a large brook, known as the Winoni-micheken, or fat-wier river, comes in from the north. At 9 miles below this, the river divides around an island six miles in length, known as Atik-minis.

The banks have been gradually increasing in height, and are here about 50 feet above the river. They still preserve the same character, presenting above high water level almost sheer walls of boulder-clay. This clay can be readily recognised as of two ages—a lower bluish-gray, exceedingly tough, compact till, with a great number of large boulders, and an upper, more friable, buff-coloured clay, with small pebbles and only an occasional large boulder. Marine clays of varying thickness cap these banks all along and yield many species of fossil shells. Character banks.

The first rocks of the Hudson bay sedimentary series are seen at 194 miles from the lake or 42 from the coast. They occur as flat-lying, fine-grained somewhat arenaceous limestones, forming the bed of the river. Four miles below, the river breaks through a gorge of these rocks, affording a section of about 30 feet of limestones and dolomites. Limestones.

Fossils collected from the limestones are found by Dr. Whiteaves to be similar to those of the Fawn branch of the Severn and of the Attawapiskat and Ekwan rivers and therefore Silurian. The strata occur in a succession of gentle minor undulations, but they preserve a general dip that accords closely with the slope of the river-bed, so that it is estimated that only about 70 feet in all of strata are exposed along the stream. Silurian fossils.

At a point 26 miles from the mouth of the river, a compound anticlinal, whose axis strikes south 70 degrees east, brings up the upper beds of a lower set of rocks, consisting of quartzites and slates, that apparently underlie the limestones unconformably. The trend of the anticlinal would carry it easterly to Sutton mill lake, where rocks of the Nastapoka series were noted by Mr. Dowling in 1901, and it seems not unlikely that these Winisk beds may belong to the same series. Older series.

Below the point at which these rocks occur and nearly to the mouth, frequent exposures of nearly horizontal beds of limestone are seen, forming low cliffs underlying the boulder clay. Along this part of its course, the river is about 30 chains wide, expanding in numerous places to three-quarters of a mile, with many islands. Limestone cliffs.

The boulder-clay banks rise to 85 feet above the level of the water, with the same irregular layer of marine clay on top, the whole capped, Peat-moss.

where fresh sections are afforded, by from 6 to 10 feet of sphagnum moss that shows very little evidence of decay. Back from the banks, the same moss-covered plain, with scattered spruces and tamaracks, extends for long distances, probably to the next river valleys on either side.

Age of trees.

Sections of trees growing along the river showed a very small annual growth. A black spruce 10 inches in diameter was found to have 270 rings of annual growth and one 6 inches in diameter 110 rings. Two 12-inch trees growing on a dry knoll showed 120 and 148 rings, respectively.

Routes east and west.

Twenty-four miles from the mouth, a river of considerable volume comes in from the east, by which there is a route to the Ekwan river. It is known to the Indians as the Mattawa. The Mishamattawa, 10 miles further down on the west side, is used as a canoe-route to the mouth of the Severn river, by way of the Shakameh river and the coast of Hudson bay.

Islands. Northern limit of trees.

For 25 miles up from the sea, the river has an average width of about three-quarters of a mile, increasing to over a mile in places and is dotted with a continuous line of islands. These islands support a growth of large spruces, down to within 12 miles of the mouth. Below this, they are covered with grasses and small bushes, with only an occasional grove of large balsam poplars. On the mainland there is the same stunted forest down to within three miles of the sea. A level, sandy, treeless plain, sparsely covered with grasses and various other plants, forms a fringe along the coast.

Estuary.

For the final 40 miles, the general course of the river is north-east. The eastern shore then bends eastward to form the coast line of the bay, and the west shore takes a course almost directly north for 8 miles to Wabukwinniashi or White-bear point, whence the coast trends westward. The estuary and neighbouring parts of Hudson bay are quite shallow. The receding tides, though having a fall of only about 6 feet, leave a wide margin of mud flats, studded with large boulders.

Buildings.

The only buildings at the mouth of the river are a small log shanty that serves as a winter outpost for the Hudson's bay company and a very creditable frame church built by the Roman Catholic mission at Albany, from lumber cut by whip-saws on the spot.

Larch saw-fly.

Tamarack trees along the river were suffering from the depredations of a dark green worm that Dr. James Fletcher identifies from description as larvæ of the imported larch saw-fly *(Nematus Erichsonii)* that has been gradually spreading over north-eastern America. The

trees were found to be slightly attacked about the mouth of the river on the 1st of August, the defoliation gradually increasing up river to the Tashka rapid, 192 miles from the mouth, where they were quite stripped of needles on August 13 and gradually decreasing again southwards. The trees about Weibikwei lake were quite untouched on the 21st of August.

Following its general course the total length of the Winisk river from Weibikwei lake to the sea is about 240 miles and its probable length above the lake over 100 miles. The descent from Weibikwei lake is in the neighbourhood of 700 feet. Length of river.

The average morning and evening temperature on the river between the middle of July and the 22nd of August was 57° Fahr. and the average noon temperature 69° Fahr. There was no frost until the night of the 22nd August and none of any severity till the 3rd of September, when ice was formed on standing water. Temperature.

The Canada grouse or "spruce partridge," ducks of many species and various waders breed along the river and a few flocks of wild geese were seen. Moose are not found beyond the southern end of Weibikwei lake, in north latitude 52° 52'. Caribou range over the whole district. Black bears are fairly plentiful and white bears occasionally come ashore from the drift ice at White-bear point. The common fur-bearing animals occur, though beaver and otter are not plentiful. White foxes were taken last winter as far south as Lake St. Joseph. Fauna.

At the mouth of the Winisk, the Indians were taking white-fish and brook trout of good size in large quantities. Further up on the river, whitefish were seen in large schools and sturgeon, doré, pike and suckers were also caught. The Indians throughout this district are fish-eaters, depending for subsistence largely upon their nets and mécheken or trap-weirs which they build with great skill, fencing off the smaller rivers and impounding all fish coming down with the current. Fish.

The 500 Indians trading at Fort Hope, as well as those scattered along the river and its tributaries, are for the most part christianized. They are divided about equally between the Anglicans and the Roman Catholics, the latter reaching the Indians by periodic visitations from the Mission at Albany, while the former maintain a resident clergyman at Fort Hope. Christian Indians.

Over the whole country examined, evidences of glacial action are plain and wherever the direction of movement is indicated it is, in a general way, southerly. The transported material clearly shows, too, Glaciation.

by its composition, a northern origin. From Weibikwei lake for 55 miles down the Winisk river, the course of the glacial striæ is about S. 30° W. with occasionally a set running S. 15° E. On the Wabitotem river, the movement was S. 40° W. Along the Albany river, between Fort Hope and the Opichewan, the striæ have a very regular direction, S. 68° W.

The volume of water carried by the Winisk, computed from two sections across the bed of the river, made about 30 miles from the mouth, at the beginning of August, when the water was low, was estimated to be 25,000 cubic feet per second.

Astronomical observations.

During the summer, 35 latitudes were taken as checks on the micrometer and track-surveys and the magnetic declination was ascertained at a number of points. On the way out a micrometer survey was made of the Albany river from Fort Hope to the Opichewan, a distance of 26 miles. The Canadian Pacific Railway was reached by way of Lake Nipigon. Brook trout of good size were caught plentifully in the rapids along this route. Mr. McInnes arrived at Ottawa on the 22nd of September.

Fossil shells.

In addition to the fossils obtained from the limestones, a collection of Pleistocene shells embracing 11 marine species, was made from the clays exposed along the Winisk river, of which Dr. Whiteaves has furnished the following list: Pecten Islandicus, Muller, Mytilus edulis, L., Cardium ciliatum, (Fabricius), Seripes Grœnlandicus (Gmelin), Macoma calcarea (Gmelin), Macoma Balthica, L., Mya truncata, L., Mya arenaria, L., Saxicava rugosa, L., Buccinum tenue, Gray, Buccinum.

Fresh-water shells.

The following mollusks, determined by Dr. Whiteaves, were found living in the Winisk river: Limnœa stagnalis, L., L. palutris, Muller, L. catascopium, Say, Planorbis trivolvis, S., P. bicarinatus, S., Unio luteolus, Lam., Anodonta marginata, S., Spherium striatum, Lam.

THE NAGAGAMI RIVER AND OTHER BRANCHES OF THE KENOGAMI.

Mr. W. J. Wilson.

Following your instructions to make a topographical and geological survey of the rivers and canoe-routes which converge at Mamawémattawa and vicinity, I left Ottawa on May 27, accompanied by Mr. Owen O'Sullivan of this department. We proceeded to Montizambert on the C. P. Railway, where we procured canoemen and provisions and on June 1 we started for our headquarters at the Hudson's Bay company's post at Mamawémattawa, taking with us in three canoes nearly all the supplies we required for the summer. We followed a hitherto unsurveyed route by White lake, over the height of land and down the Nagagami river, a distance of 208 miles, reaching the English river post of the Hudson's bay company on June 20. Mr. E.E. Vincent, who is in charge of the post, kindly stored our provisions and gave us every facility in his power for carrying on our work.

Canoe route to Mamawémattawa.

Two of the Indians whom we engaged at Montizambert for the season's work would not remain in our service, and we were obliged to hire others to fill their places. This was not easily done, as all the good men were engaged "voyaging" for the company. We were unable to start at once on a long trip, as the Indians were awaiting the arrival of the first boat from Albany with supplies and clothing, so we spent the first week in making a micrometer survey of the lower part of the Nagagami river.

After securing a full crew, we set out on June 30 to make a survey and examination of the Little Current river, a western branch of the Kenogami, which we followed for about 180 miles*. After returning to the post for supplies we separated into two parties, Mr. O'Sullivan making a track survey of the Drowning river, another western branch of the Kenogami which he examined for 135 miles, while I made a micrometer survey of the Kabinakagami river a distance of 75 miles up to the portage across to the Mattawisquia river an affluent of the Missinaibi. I also made a track-survey of the large eastern branch of the Kabinakagami which I named Ridge river.

Routes surveyed.

We came back to the Hudson's bay company' post on August 20, when we repaired our canoes and prepared for our return journey. We were delayed some days on account of the difficulty of getting canoemen. The Indians at this time of year are getting ready for their winter's hunt, and as they could not get back before the second

* The distances along rivers given in this report follow the curves of the streams.

week in October, they did not care to undertake the journey. They were also afraid that in returning they might have trouble in crossing the lakes at the height of land, as in some years these lakes are said to freeze over by October 1, or earlier.

We left on August 31 and continued the micrometer survey of the Nagagami river from the point where we turned back in June up to the source of the river in Obakamiga lake; thence over the height of land into Big Rock lake, down Gum river, White river and Natamasagami lake, connecting with the Canadian Pacific Railway at the bridge over White river, one mile and a half west of Montizambert station. This was completed on September 28, when we left for Ottawa which we reached the following day.

THE LITTLE CURRENT RIVER.

General description.

The Little Current is a branch of the Kenogami river and enters the latter about fourteen miles south of the Forks or its junction with the Albany. In a general way, it runs parallel to the Albany, its course being east-north-east except in one or two stretches where it flows almost due east. It is five chains wide at the mouth and about eight feet deep. Further up where it runs over flat dolomite strata, it is broader and at low water is so shallow that it will scarcely float canoes. There is a strong current nearly all the way with numerous rapids, often obstructed by large boulders. It flows through a comparatively flat country, no hills of any importance having been seen, until the lakes near its source were reached.

Like all the rivers flowing through the great costal plain to the west of James bay, the Little Current has no distinct valley, but flows in a canal-like ditch until the gneissic rocks are reached, when the channel becomes narrower and the adjacent country higher and more rolling. The clay banks in places rise fifty feet above the river, but generally they are much lower, usually ranging from five to ten feet. Along the river on both sides, there is a strip of well drained fertile soil on which is growing, when not destroyed by fire, fair-sized trees of spruce, poplar, balm of Gilead, tamarack, canoe-birch, and balsam-fir with mountain maple and numerous shrubs and small plants. In some places this strip is only a few chains wide, while in others it goes back a quarter of a mile or more. Beyond or inland from this, the soil is covered with a deep layer of peaty moss saturated with cold water, the forest growth being open stunted spruce and tamarack. The temperature of a small stream trickling from this muskeg was 36° Farh. in July, while the water in the river was 70° Farh. From per-

sonal observation and from information furnished by the Indians who hunt on this river I infer that this is the character of the greater part of the country underlain by the dolomite. Where the rocks are Archæan the land is better drained and therefore more suitable for agricultural purposes. It is also better wooded, spruce trees reaching a diameter of two feet or more. Unfortunately, considerable areas have been burned at different times, so that small dense second growth covers much of the ground, the trees averaging from four to twelve inches in diameter.

Large areas of muskeg.

Above the contact of the Palæozoic and Archæan rocks the river is narrower, and for fifteen miles rapids are common. In this distance there are ten portages, and as this part of the river is not much used by the Indians, the portage trails could scarcely be followed and we were obliged to clear them all afresh in order to get our canoes over. In some places the river runs in narrow gorges through the gneiss which forms steep walls thirty to forty feet high, the river itself being less than a chain wide. The uppermost portage is past a fall twenty-four feet high divided into two drops of equal height. It is also divided in the middle by an island. Above this fall, to the lake, Percy river is broader and deeper with slack water.

Portages.

Twenty-five miles up, a branch two and a half chains wide enters from the north forming part of a canoe-route to the Albany river and at eighty-five miles the largest tributary enters from the south. It is three and a half chains wide at the mouth and four feet deep, but at this point the current is rather slow. This branch forms a canoe-route to Long Lake House and is described as a very rapid river with many portages. Where this stream enters, the main river is over six chains wide (435 ft.). There are also many smaller branches entering from both sides. At 120 miles from the mouth the river opens out into Percy lake eight miles long and one and a half wide. The longer axis has an east and west direction and the lake receives two streams of nearly equal size, one at the extreme west and the other at one mile to the east. We ascended the latter, which flows from the south, making a micrometer survey for six miles, but we found progress so slow by this method that we decided to abandon it and make only a track-survey. Mr. O'Sullivan, who did this work, reports as follows: 'From the end of the micrometer survey there are three miles of rapid water, then a narrow lake five miles long. This is followed by four miles of slack water to another lake, also five miles long and one mile wide. Above this, the river has a slow current for two miles to its source in a large circular lake, six miles across, with a deep bay to the south-east. All this country is rocky and swampy and was burned

Percy lake.

probably fifty years ago. It is now covered with a second growth of poplar, spruce, canoe-birch and Banksian pine, the trees being from four to eight inches in diameter. About nine miles south-west from the outlet of the last lake, a comparatively high mountain stands out prominently.'

GEOLOGY OF LITTLE CURRENT RIVER.

Impure dolomite.

In ascending the river, the first rock exposure is two and a half miles above the mouth. It is a soft, argillaceous, reddish-brown dolomite, often interlaminated with beds of a greenish-gray colour and sometimes the rock is a mottled mixture of the two colours. It is seen in frequent outcrops for twenty miles up the river, and resembles very closely the rock found in ascending the Kapiskau river*. As far as examined these rocks yielded no fossils. Farther up, the rock is harder and varies in colour from a whitish-yellow to an olive-green. In places these rocks are highly fossiliferous and as complete a collection as time would permit was made. Dr. Whiteaves and Mr. Lambe have made a cursory examination of this collection and refer the rocks to the Cambro-Silurian and Silurian periods. A list of these fossils with a description of the localities will be given in the detailed report.

Fossils.

Archæan rocks.

Eighty miles from the mouth there is an outcrop of hornblende granitite, extending across the river for ten chains, in a series of knobs mostly covered at high water. Above this, fossiliferous dolomites and limestones extend for four miles. The first large exposure of Laurentian age is at the eighty-eighth mile, where a gray granite-gneiss outcrops. The dip is N. 15° W. $<$ 65°. This is followed by rusty-weathering, garnetiferous gneiss interfoliated with diorite-gneiss and in places with finely banded syenite-gneiss and mica schists. The last mentioned sometimes form a considerable portion of the rock. These rocks are generally well foliated and strike nearly east and west and dip north, at an angle of from 30° to 50°. They contain numerous veins of quartz-pegmatite, and coarse and fine grained diabase. Some of the pegmatite veins are almost pure red or white orthoclase. This is the general character of the rocks as far as the micrometer survey was carried. South of this, Mr. O'Sullivan reports: 'Laurentian rocks consisting of fine-grained granite-gneiss and mica-schist extend to the second lake. The rocks on the south-east shore of this lake are mostly massive mica-schists of Huronian type. The only two exposures on the opposite shore of the lake are a garnetiferous, muscovite-granite. The shore and

* Summary Report Geol. Surv. Can. of 1902, p. 222.

numerous islands of the third lake are very rocky. Massive biotite-schists and basic diorites, containing quartz veins, form cliffs in places thirty feet high.'

THE BIG DROWNING RIVER.

Mr. O'Sullivan, who surveyed the Big Drowning river, reports as follows :—

'The Drowning river runs parallel to the Little Current for seventy-five miles. It is six chains wide and averages three feet in depth. Its waters are swift, with a number of shallow rapids over dolomite ledges which had to be waded in getting our canoes up. The strongest of these has a fall of ten feet in half a mile.

'Seventy-five miles from its mouth, the river divides into two branches of nearly equal size, the one from the west, named the Kahapimegat, forming a canoe-route to Long lake. This branch which is very crooked and three chains wide, flows through a low swampy country for fifty miles; then the land rises gently for ten miles, when it becomes broken, high and rolling. Six portages were made to the 135th mile, from which I turned back.

'There are three elm groves near the mouth of the river, then for twenty-five miles, the banks are well wooded with spruce, poplar, canoe-birch, tamarack, balsam fir and Banksian pine, the trees being from four to eighteen inches in diameter. From the twenty-fifth to the fifty-fifth mile the country was over-run by fire some forty years ago and now a thick second growth of poplar and canoe-birch is seen. The woods along the Kahapimegat up to the ninetieth mile are much the same as those on the lower part of the Drowning river, some of the trees having a diameter of twenty inches. These larger trees extend only from twelve to fifteen chains back from the river; when the edge of the inland muskeg is reached. From the ninetieth to the 102nd mile the country was burned over some twenty years ago; thence good mixed timber covers the loamy soil as far as the river was followed. Forest growth.

'High clay banks extend for a distance of thirty miles from the mouth and attain in places a height of fifty feet.

'The first rock in situ occurs five miles up, where a soft reddish-brown argillaceous dolomite, lying almost horizontal is seen. The same rock is frequently met with between the eighteenth and thirtieth miles, banded with layers of a grayish colour. Fossiliferous rocks Silurian rocks.

extend from the thirty-fifth to the forty-second mile and the fossils collected indicate that the formation is Silurian. Rusty-weathering dolomite, carrying a considerable amount of iron was noticed in this stretch. No rock exposures were seen between the forty-second and the 119th mile. At the latter distance a mass of reddish-gray pegmatite-granite extends across the river. From this point to the end of the survey, a distance of fifteen miles, many exposures of Laurentian rocks were seen. Granite-gneiss, interlaminated with basic bands and a pegmatite-granite predominate. The general strike is N. 40° E. The dip is irregular but usually at a high angle.'

THE KÉBINAKAGAMI RIVER.

The Kébinakagami river enters the Kenogami at Mammawémattawa, near the Post of the Hudson's Bay Company, in latitude 50° 25′. In a general way, its course is north-westerly as far as it was surveyed. It receives several branches, chiefly from the east, as there is only a short distance between it and the Nagagami river on the west. At a distance of thirty miles up, the two rivers are only a mile and a half apart. The largest branch enters at one mile from the mouth. For a considerable distance the Kébinakagami is from two to three chains wide, with slack water except in a few places. The clay banks are from 10 to 30 feet high. Farther up, where the dolomite comes to the surface, the river is wider and in consequence shallow. From the forty-seventh to the sixtieth mile, the bed of the river is mostly a flat dolomite rock. In this distance, the stream is almost a continuous rapid, where it is impossible to pole canoes up and unsafe to run coming down on account of the smooth rock, shallow water and numerous boulders. In order to pass the worst places the men require to wade and drag the canoes up or lower them down slowly. At sixty-two miles up, the first outcrop of gneiss is seen and here the first portage is made. From this point to the portage across to the Mattawisquia, five portages are made to pass rapids and chutes. The first is half a mile long, but all the others are short.

Thirteen miles of almost continuous rapid.

Soil and forest.

The soil is the usual clay-loam and where drained is of excellent quality, but on the lower part of the river the land is so flat that there is little drainage, and muskeg prevails away from the banks. This continues up to the gneissic rocks, when the land is higher and the soil drier, though there are still considerable areas of swamp. For twenty miles up the river, the country was over-run by fire in 1901, and except small clumps of green woods in places along the stream, there is nothing standing except bare trunks of trees, and the country presents a most

desolate appearance. South of this burnt area, a second growth, probably fifty years old, covers the ground up to the first portage, and above this a recent fire has swept almost everything bare for three or four miles. Then follow green woods of small growth as far as the river was examined.

The large branch emptying into the Kébinakagami, one mile from its mouth, I have named the Ridge river. I made a rough track-survey of this stream for forty miles. Its general course is west and it resembles very closely the lower part of the other rivers examined in this region. It varies in width from two to three chains and has numerous rapids blocked with boulders. No rock exposures were seen, the banks being till and clay, containing marine shells. The water was so shallow that it was impossible to take a canoe beyond the forks from which I turned back. At this point the river divides about equally, the south branch extending a long distance up to a lake. This can be reached by canoes in high water. The other branch flows from the north-east and is not so long. I was not able to get a good sketch-map of these branches from the Indians, as none of them seemed to know the routes sufficiently well. The whole country drained by this river was burned, as far up as the forks by the fire of 1901, and only a few green trees are left. The forest growth on both these rivers is the same as that on the Little Current river.

The Ridge river.

GEOLOGY OF THE KÉBINAKAGAMI RIVER.

In ascending the Kébinakagami river, the first solid rock is met with at the twenty-first mile from the mouth, and is the reddish-brown and greenish-gray argillaceous dolomite found on adjacent rivers. This rock is seen in a few exposures for the next twenty miles. South of this there are many outcrops of a brownish and light-yellow dolomite stained in places with iron and presenting an ochry appearance. The fossils collected from these rocks show that they belong to the Silurian system. The contact between the Palæozoic and Archæan rocks is between the sixty-first and sixty-second miles. At the latter a mass of dark syenite-gneiss, interfoliated with layers of lighter colour and finer texture, crosses the river where the first portage is required. The dip is S. 40°E. $<$ 30°, but at the south end of the portage, half a mile distant, the dip is S. 20°E. $<$70°. At the second portage the rocks and the dip are the same as at the south end of the first. Then follows a mass of diabase and diorite, a quarter of a mile wide. Southward, as far as the river was examined, the prevailing rocks are granite-gneiss, interlaminated with basic bands, acidic granite, syenite-gneiss and

Contact of Palæozoic and Archæan rocks.

finely banded biotite-gneiss. Where I turned back the strike is nearly east and west and the bands are almost vertical. These gneisses are cut by small pegmatite veins, or dykes composed chiefly of feldspar. There are also small quartz veins and masses of a lenticular form.

THE NAGAGAMI RIVER.

The Nagagami enters the Kenogami river one mile and a-half above the Hudson's Bay Company's post at Mammawémattawa. It is about four chains wide at its mouth and discharges a large volume of water. For thirty-six miles from the mouth it flows with a moderate current and occasional rapids, between clay banks, 10 to 40 feet high. At this distance, the flat dolomite comes to the surface and the river becomes wider, in some places measuring 8 to 10 chains. Before reaching the first portage, there are two rapids, each about a mile long, which are too shallow in low water to float loaded canoes.

High clay banks.

For the first ten miles, the forest was destroyed by fire in 1901, and above this there is a large second growth of the usual trees, with a few small trees of elm and black ash. The larger of these trees measure from 4 to 12 inches in diameter.

Portages.

At the forty-ninth mile, the first portage occurs. It is over exposed granite rock along the bank and is 19 chains in length. In less than a mile there are two more short portages, the river having a total descent of 27 feet. The greatest fall in the river is at Highwood portage, fourteen miles further up, where for two miles there is a series of rapids and chutes with a total drop of 160 feet. The portage is 156 chains in length, but it is divided into two parts by a small lake. The country is here well wooded, some of the spruces measuring over 2 feet in diameter. There are also large canoe-birch, poplar and tamarack trees, but the south end of the trail has been recently burned. The soil is a clay loam and is of excellent quality. High-rock portage, one mile long, is six miles further up and here the fall is 102 feet. Almost adjoining this is Jackpine portage with a drop of 23 feet. Two miles and a-half south of this portage, at the seventy-eighth mile, the trial line of the projected Grand Trunk Pacific Railway crosses the river. This is 130 miles north of the Canadian Pacific line at Montizambert, measured along the canoe-route. There are altogether thirteen portages up to Nagagami lake, but none of them exceed half a mile in length, except the three named, and some are only a few chains long. For the greater part of this distance, close to the river the land is low and swampy, but at some distance back, there are undulations and low hills which afford better drainage. Old second growth timber prevails over most of this tract, but there is some good spruce and poplar near the lake.

Trial line of the projected G. T. P. Ry.

Nagagami lake is six miles and a-half long by four and a-half wide, and in places, not far from the western shore, it is 40 feet deep. Above the lake the river is much smaller and is very crooked with numerous rapids and boulders. In places the overhanging trees almost meet from opposite sides. Between Nagagami lake and Obakamiga lake, a distance of twenty-eight miles, there are nine portages. Elbow portage is one mile long and has a fall of 35 feet, and Loop portage, two miles further south, is 48 chains long with a fall of 33 feet. All the rest are short. Looking southward from Nagagami lake, the country is somewhat hilly and seven isolated peaks are visible rising 500 to 700 feet above the lake. To the east, one or two low hills are seen but north and west the country is comparatively flat. The country between the lakes is wooded with the usual trees, but large areas have been burnt thirty years ago or more and are now covered with a dense growth of small spruce and poplar. **Nagagami lake.**

The Nagagami has several tributaries. The largest on the west side rises near the height of land and enters the main river twenty-two miles from the mouth. The chief branch, the Nagagamisis, flows from the east and falls 30 feet in a foaming cataract over jagged rocks into the river one mile below Highwood portage.

Obakamiga lake is about twenty miles long and extends south to the height of land. It is largely surrounded by granite hills, some of which are bare and some covered with a small second growth of timber interspersed with clumps of the original forest. A portage, three quarters of a mile long, is made from Obakamiga lake across the height of land into Big Rock lake, the latter draining into Lake Superior. Obakamiga lake is 56 feet higher than Big Rock lake. The canoe-route then follows a small winding stream, named Gum river for eleven miles. There are three portages in this distance. One, the Wigwam, is 131 chains in length and about midway it has a small lake upon it. The land is generally low and thickly wooded with fair-sized spruce and poplar. The Wigwam portage is over a sandy tract with a scattered growth of Banksian pine. The country below the portage is of the same character as above it. There is a considerable proportion of burnt land and some second growth. The Gum river below the Wigwam portage is only 20 to 30 feet wide and very crooked. There are large areas of good soil and others of sandy terraces covered with Banksian pine. **Obakamiga lake.** **Forest growth.**

The Shabotik river is about a chain wide where the Gum river enters it, and from this point to White lake, a distance of fifteen miles, there is only one short portage. From the portage to the lake the river is broader than before with slow current. The soil along this stream is **Natamasagami lake.**

generally good and there are some large spruce and poplar trees. White or Natamasagami lake is over thirteen miles long and is surrounded by low rocky hills, some of which are well wooded and others recently burnt and bare.

GEOLOGY OF NAGAGAMI RIVER.

At thirty-five miles from the mouth of the Nagagami, the first dolomite is seen *in situ* in the bed of the river, and a short distance farther up there is a cliff, twenty feet high, along the west bank. The rock here is of a grayish-drab colour, rather soft and intermixed with reddish-brown and mottled bands. It is of an argillaceous character, containing twenty-seven per cent of magnesium carbonate and thirty-one of calcium carbonate. In ascending the river, the rock becomes a purer dolomite of a light yellowish colour and fossiliferous, with ochry bands. The fossils are of Silurian age.

Impure dolomite.

Outcrop of granite-gneiss.

Between the exposures of Sedimentary and Archæan rocks there is only a distance of 110 chains, but here, as on the other rivers examined, the contact is covered by clay. The first outcrop of the Archæan is at the north end of the first portage and consists of a granite-gneiss with veins of epidote, dipping S. 20° W. $<$ 20°. At the south end of the portage, the rock is a chloritic-quartz-syenite and this extends up to the next portage, twenty chains distant. Then follows a dark gray schist, well foliated and striking N. 85° W., with the layers vertical. This continues for twenty-six chains to the third portage, where it changes to a pyritiferous schist and forms the matrix of a conglomerate. The pebbles, which form a large portion of the mass, are largely granitic and are all elongated in the direction of the strike. They vary in size from mere specks to a foot or more in diameter. A few are nearly round but more are angular. This conglomerate is about five chains wide measured across the strike. Immediately south of this the rock is a fine-grained schistose greenstone, the vertical laminæ striking S. 85° E. There are also bands of hard mica-schist with deep cavities on the weathered surface. These rocks extend for over a mile and are succeeded by typical mica-schist.

Conglomerate.

Kinds of rocks.

From this southward to Natamasagami lake, the rocks are granite-biotite-schist, syenite, mica-diorite-gneiss, garnetiferous pegmatite, granitite, syenite-gneiss, quartz-syenite-porphyry, aplite, etc. The strike varies considerably, but is generally nearly east and west and the dip is usually at a high angle or vertical. The gneisses are frequently cut by dykes of pegmatite, quartz and diabase. A good example of the latter is seen at a short portage north of Jackpine portage where a

dyke, eight feet wide, cuts the gneiss at a small angle, and stands out very prominently.

The rocks, as far as seen, on the east shore of Natamasagami lake are granite and biotite-gneiss for a considerable distance from the north end of the lake, but beginning about seven miles from Montizambert, for over three miles south the rocks are hornblende schist, acidic tuff, and basic hornblende-porphyrite.

Geological divisions.

The Silurian rocks extend, in a general way, about fifty miles south of the English river post, as seen on the Kébinakagami and Nagagami rivers and about eighty-five miles west on the Little Current. South and west of this the Laurentian gneisses and granite occupy a large area. A narrow band of Huronian crosses the Nagagami river at the Three Portages, and a small area of the same age occurs on Natamasagami lake, and another on O'Sullivan lake at the headwaters of the Little Current.

Glaciation.

Fossiliferous clay, holding slender forms of *saxicava rugosa*, was found along the lower parts of all the rivers surveyed. Boulder clay underlies this Leda clay and contains the same kinds of boulders as were enumerated last year.* Striæ were noted on the Nagagami route, the Little Current and other rivers. There are two principal courses, S. 20° E. and S. 20° to 40° W. The evidence of southward movement is unmistakable.

TIMBER AND FAUNA.

Several groves of elm and black ash were noted in the area examined. With these exceptions the trees and the smaller plants are mostly the same as those mentioned in my report of last year, p. 239.

The following animals are hunted for their fur in this region : muskrat, marten, mink, beaver, otter, ermine, fisher, lynx, fox, bear and wolverine, and for food, moose, caribou and Virginia deer.

The principal fish are sturgeon, whitefish, pike, pickerel, speckled trout and suckers. Mr. Vincent informed me that sturgeon are fairly plentiful and are caught at English river post up to six feet in length ; those four feet long are common. Speckled trout are very abundant, especially in the Nagagami and Little Current rivers. They rise to the fly freely and average seventeen inches in length.

A small collection of insects was made, a list of which will be published later. Among the butterflies is *Papilio machon* L. var. *Alaska*

* Summary Report Geol. Surv., Can., 1902, p. 226.

Insects.

Scudder. Dr. James Fletcher, Dominion Entomologist, says as far as he is aware this species has not been taken elsewhere than in Northern British Columbia and Alaska.

Mr. Owen O'Sullivan, as formerly, rendered valuable assistance and did his work most satisfactorily.

We are indebted to Mr. E. E. Vincent, English river post (at Mammawémattawa) for aid in our work, as acknowledged on a former page, and to Mr. S. B. Barrett, in charge of the Hudson's Bay Company's post at Montizambert for kind hospitality.

The Temagami District.

Dr. A. E. Barlow.

Office work by Dr. A. E. Barlow.

The first of the year previous to the beginning of field-work was spent by Dr. A. E. Barlow and Mr. O. E. LeRoy in making detailed petrographical examinations of the more important rock-types collected by some of the staff during the preceding season. In addition to this, considerable progress was made with the details necessary for the completion of the report on the Sudbury nickel deposits. A geological map in two sheets, showing the area immediately surrounding the mines of the Canadian Copper Company at Copper Cliff, Ontario, was prepared on a scale of 400 feet to an inch. Besides this, two smaller sheets, each on a scale of 1 mile to an inch, were compiled to show the general geology of the area in the vicinity of the Southern Nickel Range. Of these, the westerly map, known as the 'Victoria Mines Sheet,' has been issued, showing the distribution of the various rock-masses. No attempt, however, was made on this plan to separate the nickel-bearing norite from the older green schists and diorite, as it was not possible, in the time at our disposal, to do this in detail over the whole area. During the progress of the work on this western area the great importance of such a division was realized, and accordingly, on the eastern map, known as the Sudbury Sheet, this separation was effected, showing in a very striking way the prevalence of the deposits of the nickel and copper-bearing sulphide along the borders of the norite. This map will shortly be issued, as well as the larger and more detailed geological map of the area immediately surrounding the Copper Cliff and Murray mines. Some time was spent in the determination of rocks sent by Messrs. Robertson and Carmichael of the British Columbia Department of Mines. In this connection it may be remarked that such determinations of isolated specimens, often obtained during a hurried visit to a prospect or a mine, and usually collected in very close prox-

Progress of report on Sudbury nickel deposits.

Work done for Bureau of Mines, B.C.

imity to the ore body, seldom afford very useful or accurate information in regard to the outcrop as a whole. A detailed examination of a considerable area, accompanied by critical petrographical studies of the different rock-types, is usually necessary before any very complete and accurate statement can be made with regard to the occurrences.

Geological excursion to Lake Superior iron district.

Through the courtesy of the acting Minister of the Interior, Dr. Barlow, in company with Mr. A. P. Low, also of this Survey, took part in an excursion to the iron ranges of Minnesota and Michigan. This excursion was under the personal conduct of Dr. C. K. Leith, Professor of Geology at Wisconsin University and author of the monograph issued by the United States Geological Survey on the Mesabi iron range. It was fully intended that Professor Van Hise would also accompany the party on this trip, but urgent business reasons prevented him from doing so. Dr. J. Morgan Clements, who is the author of the forthcoming report on the Vermilion iron range, explained the structural relations of the component rocks and ores outcropping in this area, while Dr. Leith furnished the results of his studies of the Mesabi iron range. Drs. Grant, Hobbs, Weidman, and also W. M. Merriam, geologist of the United States Steel Corporation, accompanied the party. In addition about thirty post-graduate students of Wisconsin, North-western and Chicago Universities were present. The excursion lasted from April the 19th to 29th, and it is believed was productive of results which will greatly assist us in the examination of the Canadian occurrences of similar iron-bearing formations, while at the same time a further knowledge was gained with regard to the structural relations of the enclosing rocks. One day was spent in examining the Vermilion range in the vicinity of the Soudan mine at Tower. Two days were spent on the Mesabi range and the principal mines at Biwabik, Eveleth, Virginia and Hibbing were visited. On the return journey, one day was spent at Ironwood and another at Ishpeming, examining the iron-bearing formation of the Penokee-Gogebic and Marquette districts. Two days were also spent in the copper country, extending from Houghton to Calumet. As a result of these examinations the belief is held* that the Vermilion iron range of Minnesota is very closely related, if not identical in character and age with the iron-bearing ranges outcropping in the vicinity of Temagami lake. Both have highly inclined attitudes with very brilliant associated jaspers. Both are enclosed by greenstones and green schists or sericite schists (altered quartz

*Dr. Barlow alone is responsible for the beliefs, opinions, comparisons, etc., mentioned in this report, as to the ferruginous rocks of the Lake Temagami district and its geology in general.

porphyries and porphyrites), but, while in the case of the Vermilion range the greenstone is, for the most part at least, basalt, some of that present in association with the Temagami ranges is intrusive, although portions are crushed amygdaloidal diabases and porphyrites. In the Temagami ranges, however, the iron ore is mainly magnetite with subordinate hematite, while in the Vermilion range these conditions are reversed and hematite prevails.

Departure for the field.

Mr. LeRoy left Ottawa for Temagami lake on May 15, Dr. Barlow leaving four days later. A few days were spent with Professor C. R. Van Hise and Dr. C. K. Leith in a preliminary examination of several of the iron ranges and in a general geological reconnaissance of the area between the Northeast Arm and Obabika lake. This completed, Dr. Barlow returned to Ottawa on May 29, leaving Mr. LeRoy in charge, with instructions to work out the geological associations of the Northeast Arm iron range. The month of June was taken up in details of office work, and in work on the Haliburton map-sheet. From the 4th to the 10th of July Dr. Barlow was working in Montreal with Dr. F. D. Adams, of McGill University, in connection with a report on the Haliburton district.

Magnetic work in exploring iron ranges.

To insure a more accurate mapping of the Temagami iron ranges it was decided to seek the assistance of magnetic measurements in order to determine more closely the position of the iron formation. By permission of Dr. Haanel, Superintendent of Mines, and with the approval of the Hon. Mr. Sifton, Minister of the Interior, Mr. Erik Nystrom, assistant to Dr. Haanel, was sent with Dr. Barlow to do this part of the work. Leaving Ottawa on July 22, Dr. Barlow and Mr. Nystrom arrived two days later at Mr. LeRoy's camp on O'Connor island on the Northeast Arm of Temagami lake. A base line was cut out and chained, starting from a point almost directly north of a small island west of the Ferguson mine, Location B, and running thence to the Tetapaga river, a distance of about 125 chains. This line followed roughly the direction of the jaspilyte band, the bearing having to be changed three times in the distance covered. At an interval of every five chains, cross lines at right angles to the main line were measured from the starting point to within about 14 chains of Tetapaga river. Observations were made for both vertical and horizontal magnetic intensity at a distance of every chain (66 feet) along these lines, by means of the Thälen-Tiberg magnetometer. By means of these observations it was possible to trace the gradually curving iron formation throughout a distance of over 2¼ miles, even through intervening swamps where no outcrops occur. In many instances the comparatively thin covering of moss and turf was removed in order to check

these observations by noting outcrops of rocks of the underlying formations. It was also possible by magnetic means to subdivide the iron formation into several smaller bands, which are fairly continuous over considerable distances and approximately parallel to one another. Besides these there are usually smaller lenticular masses of the jaspilyte, which are also rather closely parallel to the larger belts. The larger and more continuous bands of iron formations are separated from one another by considerable masses of the associated green schists, which are either altogether barren of the jaspilyte or contain only occasional thin laminæ of this characteristic material. The continuity of even the more solid bodies of iron formation is broken by the occurrence of thin layers of slaty or schistose rock. A somewhat more detailed magnetic survey was made of one of the mining locations which comprise the Northeast iron range, known as E. T. W. 339. For this purpose a line was run connecting the southwest and northeast corners of this lot. At right angles to this line and at intervals of every chain (66 feet) cross lines were run at right angles. Magnetic observations of both the vertical and horizontal intensity were made at distances of half a chain (33 feet) along these lines. By this means an accurate delimitation of the iron formation was effected over the whole lot. This work being completed, Mr. Nystrom returned to Ottawa on August 26. Maps showing the details of these magnetic observations have been prepared by Mr. Nystrom, and are filed for reference in the office of the Superintendent of Mines. The results obtained will be incorporated on the general geological plan of the area.

Detailed magnetic survey of Location E. T. W. 339.

Geological work on this district was commenced in 1887 by the writer of this report, who was then acting under instructions from Dr. Robert Bell, as his assistant. Only two months of the summers of 1887 and 1888 were devoted to this work, and by far the greater portion of this time was occupied in some of the many topographical detailed surveys necessary in a region concerning which but little had hitherto been known. The geology done was merely incidental, and necessarily subordinate in a way to the topographical survey, but as many observations regarding the nature and distribution of various rock-formations were made as was possible in reconnaissance work of this kind.

Work done in 1887.

In the survey of Temagami lake, one of the bands of iron formation was noticed on the Louis islands in the Southwest arm, and the characteristics of the outcrop were described.* The occurrence of

Discovery of iron formation.

* Annual Report, Geol. Surv., Can., Vol. X. (N.S.), 1899, p. 151, I.; (Publication No. 672).

magnetite on Temagami island in association with pyrite, pyrrhotite and chalcopyrite, was also noticed.† In 1888 this topographical work was continued, as was also the geological reconnaissance, and a number of the more important lakes and streams in the vicinity of Temagami were thus surveyed and examined. During the progress of these, the occurrence of iron ore was noticed on Vermilion lake,* and a belt of jasper and iron interbanded with one another was described as outcropping near the west end of Turtle lake. The full importance of these discoveries, however, was not at first realized, but renewed activity in iron mining and more complete descriptions of the Lake Superior occurrences turned attention to our own iron formations. The report, therefore, of the discovery of these iron formations, and the communication of the fact to the Bureau of Mines of Ontario, in the autumn of 1899, should have been accompanied by some such statement as the preceding one. The prospectors went into the field with the Geological Survey maps in their pockets, and in possession of the knowledge that in the localities specified and shown on the maps iron-bearing formations were known to outcrop. To Daniel O'Connor of Sudbury, the veteran prospector, belongs much of the credit for the tracing out of most of these iron formations, while at the same time his earnest and persistent advocacy of their economic importance has been one of the most powerful factors in directing public attention to them.

Report by Prof. W. G. Miller.

The first detailed report of the Temagami iron ranges is that written by Prof. W. G. Miller,‡ but as explained by the author, 'as the Director of the Bureau of Mines was anxious to have the report published as early as possible, time was not permitted, through pressure of other duties during the winter, for the making of a careful examination of all the specimens collected while in the field. It was thought, moreover, that a description of this material would find a more fitting place in a future and more detailed report.' Pressure of other work, however, has no doubt prevented Professor Miller from giving this further information and much more detailed areal geological mapping will be necessary before any authoritative and complete account of the relations of these iron ranges and their geological associates can be written.

Four distinct iron ranges in Tamagami district.

In the Temagami district there are four separate iron ranges, known as follows :—

1. Northeast arm range.
2. Vermilion range.
3. Ko-Ko Ko range.
4. Austen Bay range.

† Annual Report, Geol. Surv., Can., Vol. X. (N.S.), 1899, pp. 144 and 152, I.
* Annual Report, Geol. Surv., Can., Vol. X. (N.S.), 1899, pp. 145 and 152, I.
‡ Annual Report, Bureau of Mines, Ont., 1901, p. 160.

The iron ore in all of these ranges, thus far encountered, is a silicions magnetite interbanded with variously coloured jasper and chert. In some instances a small proportion of hematite is present, but this very seldom exceeds 25 per cent of the whole. Some of the richer bands contain as high as 55 per cent of metallic iron, but these are exceptions, although large quantities of ore could be secured which would average between 40 and 45 per cent. This association of the magnetite and silicia is extremely intimate, and even the richest portions of the bands contain a high percentage of this latter mineral. It is possible, however, to bring this ore to Bessemer grade by magnetic concentration, as shown by J. Walter Wells.* A specimen of an average sample showing 42·89 per cent metallic iron was crushed to 0·10 of an inch, and finer, and passed through a magnetic separator. The 'heads' or first concentrates show 57·28 per cent of metallic iron. These 'heads' when passed through the separator a second time gave a product which assayed 65·20 per cent of metallic iron. In the many assays made no titanium dioxide has been found and only an average of about 0·01 per cent sulphur and 0·02 per cent of phosphorus. None of the higher grade secondary deposits of hematite have yet been discovered, but very little has been done in the prospecting of these ranges except their delimitation at the surface. Extensive stripping, together with the digging of test-pits, as well as diamond drilling, will be undertaken by some of the owners of the mining locations as soon as the railway reaches the shores of Temagami, which will be about the beginning of June next year.

Magnetic concentration of magnetite-bearing jaspilyte.

A geological map has been prepared on a scale of 40 chains to an inch, and will accompany this volume which will show the outlines of both the Northeast arm and Vermilion iron ranges, as well as the distribution of the various associated rocks.

Geological map.

The Northeast arm range has received more attention and study, not only because of its proximity to the projected Ontario government railway, but also because, in extent and geological association it is one of the most promising. The iron formation proper of this range, or the silicious iron ores with their interlaminated jasper, starts about one-tenth of a mile west of the north end of Crooked or Snake Island lake, and passing beneath the waters of Turtle lake, ends in a swamp about 14 chains from the Tetapaga river. The whole band, therefore, is nearly 5¼ miles long. In this distance it varies in width from 200 to 500 feet.

Limits of Northeast Arm iron range.

The Vermilion range, commencing a little to the east of Vermilion lake, runs in a south-westerly direction for about three miles to the

Extent of Vermilion iron range.

*Annual Report, Bureau of Mines, Ont., 1903, p. 336.

west of Iron lake. To the northeast it is interrupted by a mass of greenstone, while the western end passes beneath the drift. It cannot extend much further in this direction, as a tongue of granite comes in a short distance west of this lake. The widest portion just south of Iron lake measures over 1,000 feet.

Preliminary examinations of Ko-Ko Ko and Austen Bay iron ranges.

Preliminary examinations of the Ko-Ko Ko and Austen Bay ranges were made, and both apparently occupy a similar geological horizon. The Ko-Ko Ko range is famous for the brilliancy of colour of the associated jaspers, while the Austen Bay band contains only a small amount of this mineral, being replaced to a great extent by darker and duller coloured chert. The Austen Bay band is much broken up by later intrusions, chiefly diabase and granite.

Conclusion by Van Hise.

The conclusions reached by Professor Van Hise and his associates, after their detailed examination of the Minnesota and Michigan iron ranges, is that a cherty iron-bearing carbonate is the chief original rock from which the iron-bearing formations and ore bodies have been produced. It is stated by Professor Van Hise that iron sulphide has contributed by its decomposition to the formation of these ores, but not to any large extent. Dr. Bell has shown* that there is little doubt the great mass of hematite at the Helen mine in the Michipicoten district, has resulted from the local decomposition and alteration of the carbonate of iron, mostly in quartzose and cherty layers, which occurs as a wide belt, traceable in the unaltered form, both east and west of the hematite mass. On the surface of the hill, where oxidation of the siderite has progressed inwards about half an inch, leaving that amount of brown hematite, it is found that grains of pyrite, which were scattered through the siderite, still remain unaltered, going to show that pyrites is changed with comparative slowness. This cherty iron-bearing carbonate is found in connection with the whole of the Lake Superior iron ranges, with the exception of the Mesabi, where iron silicate has evidently been the source of the ore. The changes, or metamorphism, in connection with these occurrences, and the production of bodies of iron have been mainly along two lines: 1st. The production of amphibolitic and magnetitic quartz-rocks or schist, and occasionally also pyroxenic and chrysolitic rocks. These are the products of deep-seated metamorphism in connection with igneous intrusion. No workable ore bodies have yet been found in connection with rocks thus altered. 2nd. The development of ferruginous slates, ferruginous cherts, jaspilytes and ore bodies. These rocks are characteristic of the belt of weathering, but in many cases the production of the jasper has required

Metamorphism of original iron-bearing rocks.

---

* Summary Rep. Geol. Sur. for 1900, page 116.

two stages: namely, first, the formation of the ferruginous slates and cherts in the belt of weathering, and secondly, dehydration when the formations were deeply buried. In some cases the bodies are due to the oxidation of the carbonate of iron in place, but all the facts point unmistakably to the conclusion that the final and most important step in the production of the ore bodies was secondary enrichment by downward percolating waters below crests or slopes, where such waters were conveyed by the sloping troughs. The waters which followed the more circuitous routes carried iron carbonate; those more directly from the surface which did not pass through iron carbonate, bore oxygen. The two waters mingled and precipitated the iron oxide. Continuing, the waters ascended, and escaped, bearing the silica to be deposited elsewhere below the valleys.* Development of jaspilyte and ore bodies.

Studies of the Temagami occurrences have not yet gone far enough to justify any very definite conclusion, but the fact that outcrops of a cherty carbonate have been found in the area immediately west of Iron lake seems to throw some light on the question of the origin of these occurrences. A specimen of this, examined by Mr. Donald Locke, assayer to this department, showed iron 35·67, silica 24·95, sulphur 0·01, phosphorus 0·022, with no titanium. The information already obtained seems to show rather clearly that, in the main, at least, the conclusions reached in regard to the origin of the iron formation and iron ores of Michigan and Minnesota will apply to the occurrences in the vicinity of Temagami.† Cherty carbonate of iron found near Iron lake. Analysis.

The work of the past summer has shown clearly† that the iron formations of this area belong to a much older series than what has hitherto been described as Huronion in this district. On the geological map by Dr. Barlow the area occupied by the Northeast arm iron range is shown as occurring in the slate or middle member of the Huronian. This is incorrect. On the contrary the iron range with accompanying green schists, slates, dolomites and schistose eruptives, and intruded by granites, belong to a series which had been intensely folded, metamorphosed and considerably eroded before the deposition of the overlying conglomerate hitherto described as the basal member of the Huronian system in this region. The larger fragments in the conglomerate are principally pebbles of granite and greenstone derived from the degradation of this underlying series. The immediate junction between this older series and the unconformably overlying conglomerate is well seen at a point on the south shore of the Northeast arm Iron formation belongs to much older series than hitherto supposed. Unconformable contact between lower and upper Huronian.

* "Iron Ore Deposits of the Lake Superior Region." Twenty-first Annual Report U.S.G.S., 1899-1900, Part III, pp. 418, 419.
† In Dr. Barlow's opinion.

about fifteen chains west of the portage into Cariboo lake. Thence the line of junction runs in a northwesterly direction a little to the east of Farr's cabin, situated on the parcel of land known as Block A. Crossing the northeast corner of the lot marked on the map J. S. 5, it reaches the eastern limit of mining location W. D. 343, about five chains north of Snake Island lake. Here the junction between the two formations is very well seen on a small hill over which the east line of the location runs. This hill was stripped of the overlying moss and turf and a photograph taken, which shows this unconformity very plainly. A short distance from this point the line of junction turns abruptly to the east and with this general direction reaches White Bear lake at the rocky point a quarter of a mile north of François White-Bear's house. Here the conglomerate rests on a much fissured and squeezed greenstone, the latter rock forming the extreme point jutting out into White Bear lake. The relationship between the two rocks is everywhere distinct, the conglomerate dipping at an angle of from 12 to 20 degrees in a southerly and southeasterly direction, while the foliation of the underlying schists shows highly inclined dips to the northwest, ranging in angle from 60 degrees to nearly vertical.

Location of line of junction between lower and upper Huronian.

Geological sequence.

The geological sequence in this area is therefore as follows:—

Lower Huronion*: —Greenstone, green schist, sericite schists, slates dolomite and iron formation with intrusive granites.

Upper Huronian*:—Breccia or slate-conglomerate, slate, quartzite.

Character of rocks of lower Huronian.

The schistose rocks of the Lower Huronian may be divided into the paler coloured and more acid varieties, which are deformed quartz-porphyries or porphyrites, and the more deeply coloured or basic schists resulting from the shearing of hornblende porphyrites, basalts and diabases. The extreme deformation of the more acid types produce sericite schists, which reveal little or no trace of their original structure. In places, however, the hand specimens secured showed clearly that they have resulted from the shearing and alteration of quartz-porphyries or quartz-porphyrites. In colour they are generaly pale yellowish green, although occasionally mottled with purplish, reddish or yellowish tints. In some cases the original phenocrysts are still microscopically apparent, chiefly feldspar in yellowish, reddish, or more rarely, pale greyish colours. The least altered variety of these porphyries shows the usual more or less rounded phenocrysts of quartz, together with orthoclase and oligoclase, embedded in a ground-mass which varies considerably in texture from being a finally cryptocrystalline to moderately coarse-grained micro-granitic. The quartz phenocryst exhibits characteristic invasions and inclusions of the ground-

Quartz porphyries and porphyrites.

* Locally so-called.

mass. By progressive steps this structure is gradually effaced until in the extreme schistose varieties nothing remains but comparatively coarsely granular quartz, sericite and calcite. Some of the more massive types have undergone considerable decomposition, and the original phenocrysts of feldspar can with difficulty be separated from the equally weathered ground-mass. These more acid types pass into porphyrites which contain little or no quartz. Some of the areas now occupied by chlorite and epidote suggest the original occurrence of hornblende. Iron ore, always ilmenite, either partially or completely altered to leucoxene, is also present in considerable quantities, while calcite or dolomite is always abundant. Such rocks are of a deeper green colour and are the immediate associates of the iron formation, forming steeply pitching troughs in which the iron formation is enclosed.

Hornblende porphyrite.

Some of the deformed greenstones have evidently been formed at or near the surface, for patches of the thin sections still show the micro-granitic ground-mass characteristic of a porphyrite, passing into areas where the ophitic or diabasic structure prevails. The resulting rocks are a hornblende porphyrite and uralitic diabase. Some of the associated green schists are deformed basalts. All of these have suffered greatly as a result of shearing and decomposition, so that the component minerals in most cases show the extreme of alteration.

Diabase and basalt.

Slates on Beaver and Tetepaga lakes.

Associated with the sericite schists, and interbanded with them, are some greenish gray, or grayish, slaty rocks occurring mainly on Beaver and Tetepaga lake. They show the development of mica on the cleavage planes, with bands of varying colour. In places, also, some dark-gray bituminous or graphitic shales occur. These were noticed along the northern border of the iron range of the Northeast arm, especially near the eastern end.

Band of dolomite.

A band of dolomite, fairly continuous, extends from Ferguson mine point to nearly the end of the Northeast arm. It is generally of a pale, greenish-gray colour and very silicious. The quartzose impurities are arranged in narrow, vein-like forms, which reticulate in all directions through the mass, so that when subjected to ordinary weathering processes these stand out in relief, leaving irregular, hollow interspaces. This band weathers to a deep orange yellow, thus rendering it very conspicuous.

Dip of rocks of Northeast arm.

All of these rocks in the vicinity of the Northeast arm have a prevailing dip in a northwesterly direction, at an angle of seldom less than 50 degrees and usually varying from 65 degress to vertical. It is believed this prevailing dip is occasioned by a series of monoclinal folds, which have undergone extensive truncation. The iron formation,

judging by the magnetic observations, extends to considerable depths below the surface and probably occupies a series of steeply pitching troughs with impervious bases formed of the schistose rocks.

Dykes of olivine diabase.

Cutting these rocks at various angles are dykes of olivine diabase. The oldest set of these dykes cuts the sericite schists but they have been subjected to similar deformation and decomposition. The examination, therefore, of the thin sections gives very little information regarding their original structure and mineralogical composition. A second set cuts across the foliation of the sericite schists, but has not been subjected to the severe stresses which have metamorphosed the enclosing rocks. They show, however considerable decomposition, and have not been noticed cutting the overlying conglomerate. Still a third set of precisely similar mineralogical composition cuts even the overlying slate-conglomerate. This olivine diabase is very fresh and typical. The presence of these dykes is considered a favourabla sign, as in favourable attitudes elsewhere they often form, with the enclosing rocks, impervious basins for the collection of the secondary deposits of iron oxide.

Lower Huronian granite.

The granite associated with the Lower Huronian cuts the greenstones and green schists, and is therefore later than these. It, however, furnishes most of the pebbles in the conglomerate at the base of the Upper Huronian. This granite is extensively developed along the south shore of Net lake in the vicinity of the Narrows. It varies greatly in texture and mineralogical composition, is gneissic in places and porphyritic in others. It is prevailingly a biotite granite or granitite, but the borders are more basic and contain considerable hornblende in addition to the biotite.

Upper Huronian previously described.

There is no need here for a description of the Upper Huronian, as it has already been fully described in a former report on this district.*

EXPLORATION FOR IRON ORE.

General rules for guidance in exploration of iron ranges.

The following general rules will perhaps be of value in exploring these iron ranges and may be helpful in suggesting some of the principles which should guide those in charge in their search for the secondary deposits of iron ores, which some believe, will yet be found. They have been taken from Van Hise's monograph 'On the Iron Deposits of the Lake Superior Region.'†

1. Exploration should first be directed to outlining accurately the iron-bearing and adjacent formations on a fairly large scale with

*See Annual Report, Geol. Surv., Can., Vol. X, Part I, p. 95 et seq.
† See Annual Report, U. S. G. S., 1899-1900, Part III, p. 421.

structure sections. This should be aided by a magnetic survey, especially of the iron formation itself. [This has already been done over part of the Northeast arm iron range and has given very gratifying results.]

2. Exploration should be confined to the iron-bearing formations with but few limitations.

3. Exploration should be confined to the parts of the iron-bearing formation showing ferruginous slate, chert and jaspilyte. The presence of interbanded hematite is favourable to the existence of ore deposits. Even distribution of the iron oxide is an unfavourable sign, and uneven distribution a favourable sign.

4. Thick and pure iron formations are more likely to carry workable deposits of ore. Formations less than 100 feet in thickness have rarely yielded deposits of value. The presence of many layers of interlaminated material, such as slate or interbedded igneous rock, is unfavourable to the presence of merchantable ore deposits. However, this also has its limitation, as the broader bands of such formation may contain workable bodies.

5. The contacts of the iron-bearing formation, especially those at the bottom, are likely to be fruitful in ore.

6. The presence of an impervious formation in contact with the iron range is especially valuable. Such impervious base may be made up of slate, schist, or greenstone, or any combination of these with cross dykes.

7. Pitching troughs, or even pitching folds, are favourable to the deposition of large secondary deposits of iron oxide.

8. The more shattered and broken the iron formation, the more favourable is this to the production of ores.

9. In reference to topography, the favourable places for exploration are usually the minor depressions on the slopes of elevations.

10. Exploration should at first be shallow. Stripping and test pits should be sunk before resorting to the more expensive diamond drilling.

If my opinion previously expressed is correct, and the Temagami iron ranges are similar in character and age to the Vermilion range of the Lake Superior region, experience gained in the latter in the exploration for the workable ore bodies will be extremely valuable for our guidance in Canada. The deposits if found will likely be at the bottom of

Temagami iron range possibly same age as Vermilion.

the irony formation. As the dips are very steep the area of any given ore deposit which would reach the surface would be comparatively small. The exploration should begin at the bottom of the contacts, especially at the ends of the folds or fingers, and should pass away from these contacts. If a well-defined pitching trough be discovered in which the rock is heavily ferruginous jasper at its base, but showing no ore deposit at the rock-surface, diamond drill work would be warranted to test the bottom of the trough with the hope of finding ore deposits, which are very small where they reach the surface.

Possible existence of secondary hematite. No very definite statement can yet be made with regard to the probability of the finding of large workable deposits of iron ore in connection with these iron formations. The discovery of a considerable quantity of hematite at both the eastern and western extremities of the range is considered a very favourable sign. The geological associations and the composition of the iron formation are entirely favourable. On the other hand, the subdivision of what was at first supposed to be a solid body of iron formation into several minor parallel bands, separated by interbedded porphyrite schists and slaty rocks, has caused some anxiety, but still many of these subordinate masses are sufficiently large to contain ore bodies of workable magnitude. It is suggested that the remaining lots not yet included in our detailed examinations should be fully explored, and accurately mapped, such work being accompanied, as far as possible, by extensive stripping before the more expensive diamond-drilling is undertaken. This would be comparatively inexpensive. as the underlying rock is usually covered by only a few inches of vegetable mould or moss.

Further detailed exploration suggested.

Dr. Barlow returned to Ottawa on September 3, while Mr. LeRoy remained in the field until September 27.

Canada Corundum Co. In November (12 to 14) a rather hurried visit was made to the mines of the Canada Corundum Co. at Craigmont, Ont., for the purpose of illustrating the latest developments. Some photographs were obtained, showing the general progress of the mining or 'quarrying' of the corundum, as well as of the new and commodious mill which will be in operation early in the coming spring. This mill will be able to handle between 200 and 300 tons of ore a day, with an output of 20 or 25 tons of cleaned and graded corundum. The buildings are placed near the eastern extremity of the hill on which the mines are situated, the upper floors being approached by an easy down grade from the openings. A tramway has been built from the mill to a wharf situated on the main channel of the York river, thus affording the much needed shipping facilities. Most of the side of the hill on which the

New mill.

main openings are situated has been cleared of trees and shrubs and subdivided by a surveyor into 100 feet squares, the corners being marked by stakes suitably inscribed. Series of levels have been run for the purpose of making a contour map of this part of the property. In addition a competent geologist has been employed tracing out and mapping the various outcrops occurring in these squares, making notes in regard to any peculiarities of composition and especially of the presence and relative abundance of corundum. In places considerable stripping has been done, which has greatly assisted both the geologist and the miner in their work. It is intended that a detailed geological map showing contours will be prepared, which will no doubt be of immense assistance in laying out plans for future extension of mining operations. A report for the Geological Survey, suitably illustrated is now being prepared, which will deal rather fully, not only with the origin and geological relations of corundum in Canada, but will also furnish descriptions of the mining and concentration of this mineral.

Geological map of property.

Prince Edward and Hastings Counties, Ont.

Dr. R. Hugh Ells.

The work of the season was devoted first to making surveys necessary to complete the Kingston sheet of the Ontario series, and later to the survey of the county of Prince Edward.

Beginning on June 24, surveys were made of the district lying between the St. Lawrence on the south and the village of Morton on the north, comprising that part of the country between the southern part of the Rideau canal and the Gananoque river, to determine the position of certain outliers of Palæozoic rocks which rest upon the granite and other Archæan rocks. Subsequently a number of roads were surveyed to the west of the Kingston and Pembroke railway in the townships of Olden, Hinchinbrooke, Sheffield and Kennebec, in order to determine the limits of the several formations in this direction.

Surveys in the Kingston district.

On July 9, the surveys of the area south and west of Madoc, necessary to complete the county of Hastings were commenced, and this work was continued to the end of the month.

Surveys in Prince Edward Co.

Crossing over to the county of Prince Edward on the Bay of Quinté, all the roads in this area were surveyed in order that map-sheet No. 110 might be compiled, and work in this direction was finished on August 28.

GEOLOGY.

Trenton and Black River formations.

In the area between Madoc and Trenton, including the western portion of the county of Hastings, the delimitation of the boundaries between the Trenton and Black River formations, which are the only two belonging to the Palæozoic division seen in this district, was made as closely as the large amount of drift which occupies the surface for many miles would permit, and the outline of the underlying Archæan was also fixed. The line between the two former was found to be very irregular, but the horizons of each were fairly distinct, owing to the abundance of fossils at many places.

Prince Edward Co.

In Prince Edward county the rock-formation was found to be almost entirely of Trenton age. At one place an outcrop of granite was seen, rising through the Trenton limestone, which is lying against it at angles of 30 to 45 degrees. The limestone is somewhat altered along the contact, but the contained fossils are readily recognizable. The granite is largely composed of red feldspar with quartz, and the outcrop is nearly a mile in length, but not very wide. The locality is about 180 chains south of the west arm of the Bay of Quinté, near Ameliasburg post office.

Fossils.

Over much of this area the Trenton limestone abounds in fossils, but there appear to be no minerals of economic value.

Lake of the Mountain

An interesting feature is the Lake of the Mountain near Glenora, about five miles east of Picton. This lake is near the top of a plateau of Trenton limestone which rises to a height of about 200 feet above the Bay of Quinté. The elevation of the lake is about 150 feet, A considerable stream of water flows from the north side to the Glenora mills, and this has led many persons to suppose that the water of this lake is derived from some far-away source through an underground channel. The fact however, that the surrounding area lies at an elevation of from forty to fifty feet above the surface of the lake, and that several small streams drain into it, will account for the outflow without the necessity of a remote source of supply.

Potsdam sandstone.

In the area north of Kingston Mills, towards Morton, outcrops of the Potsdam sandstone were recognized at several points resting on the granite and gneiss. The rocks overlying the sandstone are seen at Joyceville, about two miles south of Washburn locks on the Rideau canal, and consist of hard fine-grained, and sometimes cherty, limestones with thin shaly partings, which are regarded as the base of the Black River formation, thus indicating a well-defined break in the Palæozoic sediments, since there is no indication of either the Calci-

ferous dolomites or the Chazy shales in this area. The most westerly recognized outcrop of the Potsdam sandstone yet seen in the Kingston area is about five miles east of the village of Tamworth, where several small outliers occur, resting partly on red granite and partly on the crystalline limestone. There is a deposit of red hæmatite at this place, but no large ore-body has yet been disclosed. The hæmatite appears to be derived from the basal red beds of the Potsdam through a process of leaching, and a considerably body of the red oxide now occupies in part a swampy area of the vicinity, resting upon the underlying crystalline rocks. In this respect it somewhat resembles the hæmatite deposit at the Playfair mine, and in the event of fissures existing in the underlying rock, similar deposits of hæmatite may also be found here. Of this however, there are no superficial indications, the excavations not having as yet penetrated below the surface deposits. While the oxide extends over a considerable space, it is rarely sufficiently solid to constitute a true ore of iron. Black's iron mine.

Among other places visited in the course of the work in this field was the zinc-blende mine on lot 3, range V, Olden township. This is near the north side of Long lake. The country rock at the mine is a coarsely crystalline limestone cut by granite and pyroxene, the general strike being N. 70° to 80° East. Richardson's zinc mine, Olden.

The blende is associated with galena and iron-pyrites, and occurs in lenticular pockets, which widen out in places into bunches of ore containing hundreds of tons. No true vein structure is visible, but the mineral is seen at several points and extends over a considerable area. The mining is done by an open cut which has a depth in places of about 80 feet, and the ore is graded into two classes as extracted; the rich massive ore, which is said to contain as much as 48 per cent of zinc, being shipped direct as No. 1, while the lower grades are cobbed from the calcite mass and concentrated on the spot.

The mode of occurrence is quite distinct from that seen at the blende deposit on Calumet island in the Ottawa river, where it is found in a hard diorite mass with gabbro and granite. Some hundreds of tons have been extracted and a quantity has been sent to Swansea. While pockety deposits are always of an uncertain nature there appears to be a good prospect for a considerable development at this place.

The actinolite mines in Elzevir township occur in a hornblende schist rock which forms ridges running in a northeast direction. Portions of the rock are altered to an impure serpentine, and the mineral is in zones or bands; sometimes in pockets, generally along the sides of the ridges, ranging from a few inches in thickness to several feet. It Actinolite of Elzevir

occurs in the form of crystals, of which both the stellar and the platy or tremolitic varieties are recognized. Some of the latter are in broad sheaves with a length of four to six inches by two to three inches in breadth. The smaller sizes up to one and two inches are regarded as the best for milling stock, the stellar variety being generally too brittle to be made into good fibre. The serpentine portion of the ridges appears to be almost devoid of the actinolite.

Faults.

Evidences of faults are seen at several places and the actinolite bands are often cut off by these breaks, the slicken-sides being well exposed. At the eastern end of the property a shaft has been sunk to a depth of about thirty feet along one of these faults, the underlying wall being a soft chloritic rock, in which stellar crystals are disseminated to a depth of several inches, while the south side of the shaft is a mass of the tremolitic variety. The dip of the slide here is S.25° E. < 65°–70°.

Output.

The amount of fibrous mineral from the output of this mine is stated to be about 35 to 40 per cent, and this upon milling will yield about ten per cent of mill-fibre. The value of this fibre, which is used for felts and for boiler coverings, is said to be \$20 per ton. The fibre remaining after the first separation, is ground and makes what is known as 'Asbestal', extensively used as a wall plaster, and valued at \$6 to \$7 per ton.

The milling plant is located at the village of Actinolite (formerly Bridgewater), and is on the same general principle as the mills for the extraction of asbestus at the Eastern Townships mines, though much less elaborate in construction.

Another mill is located at this place, owned by Mr. Joseph James, in which is utilized a mixture of talc or impure soapstone with scrap mica, the resulting ground material being sold for a fire-proof roofing material.

The Recent Landslide on the Lièvre River, P.Q.

Dr. R. W. Ells.

Area of the landslide.

The locality in which this disaster occurred is on the west bank of the Lièvre river, about 13 miles above Buckingham village and 17 miles from its junction with the Ottawa, a short distance below the Little Rapids lock and dam. The slide comprises an area of nearly 100 acres, of roughly triangular shape, with a base on the river of 28 chains and a depth inland to the foot of the mountain of about 35 chains, including a rich tract of excellent clay land. At the back of the disturbed area

is a ridge of granite and gneiss belonging to the Laurentian formation, having a slope towards the river in a north-east direction. The surface of the clay flat between the mountain and the Lièvre is nearly level.

In character these clays are usually arenaceous and sometimes silty, and the causes of this landslip, which is similar to several others which have taken place in the valley of the St. Lawrence, have been well explained in a report by Dr. Chalmers on a landslip that took place on the River Blanche, Portneuf Co., in 1898, as follows:—

"(1.) The (local) silty and arenaceous character of the Leda clay rendering it capable of absorbing and retaining a large amount of water, and (2.) the increased precipitation during the season when these landslips occurred, which saturated the deposits and gave them greater weight than usual. These conditions doubtless produced unstable equilibrium of the beds, resulting in displacement and a flow of the semi-liquid portion. The more coherent clays, breaking down as described, and mixing with the soft material, produced a tumultuous mass of mud, clay and sand, which descended into the nearest valley." Causes of landslides.

The same remarks will doubtlessly apply to all the localities in which these landslips have occurred, among which may be mentioned one on River Ste. Anne de la Perade, near St. Albans, 1894, and another on the River Maskinongé, evidently in 1840, and described by Sir W. E. Logan many years ago. Former landslides.

The disaster on the Lièvre river occurred on Sunday morning, Oct. 11th, 1903. There had been heavy rains throughout the district for several days previous, so that the whole country was saturated, and numerous small streams descended from the slope of the ridge at the back of the clay flat. Along the foot of this ridge the clay is underlain in places by a deposit of boulders and other debris from the rocks of the mountain, so that there was a good opportunity for the water to penetrate beneath the mass of the clay to some distance. One of the small streams crossed the clay flat and flowed into the Lièvre, and for several days subsequent to the slide much water could be observed issuing from the sides of the break and forming pools on the broken surface of the area. Character of the area in the Lièvre district.

It is evident therefore that the clay body became saturated or charged with immense quantities of water thus greatly increasing the weight of the mass. If then an interstratified layer of silt became liquified the pressure of the overlying clays would tend to force out the whole mass in the direction of least resistance, which in this case was the bank of the river. Cause of the disturbance.

Such was the pressure exerted that the clay was pushed entirely across the stream which here had a width of nearly six chains, and masses of it were deposited on the east bank to a height of from 20 to 30 feet. The portion of the river thus filled is about 30 chains in length but, owing to the fact that the river bed was also composed of smooth clay at this point, the increased force of the water caused by the damming of the stream, carried great masses of the clay, in one place with a hay-barn on the surface, down the stream for some hundreds of yards.

Amount of displacement.

The amount of displacement in the direction of the river was nearly five chains or by actual measurement indicated by the break in the main road which traversed the area, about 310 feet. The remains of this road could be readily traced at intervals across the whole extent of the broken ground showing many curious dislocations, small side throws and upheavals. The main displacement appears to have been at the northwest angle of the disturbed area, from which the mass seems to have gradually swung out towards the river with the south-east angle as a pivot.

The mass of disturbed clay is broken across by numerous heavy fractures which have a general course at right angles to the direction of the movement. In places, huge masses of the clay have been forced upward along these fissures and show beautifully striated and smoothed surfaces as the result of the movement. Along the south-east side of the area the displaced mass has formed an escarpment rising from the undisturbed portion to a height of, from 10 to 20 feet. This is just in the rear of Mr. Brazeau's house, the line of fracture crossing, to the back of his residence and demolishing his stables. Sharp crevasses evidently opened at this place as elsewhere and suddenly closed, since a number of cattle which were standing apparently on his roadway were engulphed and some of them buried out of sight.

Broken character of surface.

At one point on the river, about 100 yards north-west of this house there is a mass of the original clay flat, well wooded, and undisturbed, the moving clay having divided against a point about 350 feet inland and passed partly to the north and partly to the south. Along the flanks of this mass the striated sides of the clays could be well seen. Further inland, near the old road, there is a large mass of, from 4 to 5 acres which was bodily moved for a distance of about 200 feet and on which no disturbance could be seen, but deep crevasses of, from 15 to 18 feet surround it on every side. Near this block a house (Clement's) still stands in its original upright position together with a well of water which was not drained, while the sheds within a few feet to the north were tilted in all directions.

The outline of the break on the south side is fairly regular, but on the north side in the direction from the mountain slope to Duncan McMillan's house the fissure is quite jagged. Just before reaching the house which is on a knoll near the west end of the lock-dam, the break was deflected to the south and apparently followed a depression in the surface by which it reached the Lièvre just below the dam. Outlines.

The movement of the clay was apparently not along the glaciated surface of the underlying gneiss, as the rock is not exposed at any point in the disturbed area, but is seen at one point on the bared surface of the slope of the ridge where it shows ice markings in the direction of the present river course. Along this flank the whole mass has been torn away abruptly, bearing with it the standing trees with which this portion was covered, and carried directly outward for some distance. Some of these trees are as erect as before the slide occurred. Movement of surface on clays not on rock.

It would seem therefore that the real cause of this disturbance was the saturation of the clay beds, which are arenaceous in places, and then by the softening of some interstratified silty layer, which was apparently about twenty feet from the surface, the mass moved forward, sometimes in block, but generally in a much broken up condition. The movement was rapid and attended apparently with but little noise since the residents were quite unconscious of the disaster till the disturbance was nearly over. The supposition on the part of several persons that the cause of the disaster was the percolation of the water from the river, owing to the construction of the lock dam, is not maintained, since in that case the direction of the slide would have followed the course of the river, while in fact the movement was either directly across the stream or, in the upper part of the displacement, was actually up stream as the lock basin was completely filled with clay from the outflow.

The force of the water which was backed up-stream nearly to the foot of the High Falls will doubtless soon wash away the deposited clays from the river channel, so that within a few months the stream will be again flowing along its original course.

SURFACE GEOLOGY OF THE SOUTHERN PART OF THE PROVINCE OF QUEBEC.

Dr. R. Chalmers.

Work in winter of 1902-03.

Dr. Chalmers spent the winter of 1902–03 in routine work in the office, chiefly in compiling the data obtained in the field in 1901 and 1902. The results are, however, incomplete, as far as they relate to the province of Ontario, and some further field-work is necessary before a full and detailed report can be prepared.

Instructions for season of 1903.

'The instructions I received from you in May last, concerning field-work for the season, were to examine the marine clays and sands, as well as the other surface deposits of the St. Lawrence valley, from the city of Quebec westward to Lake St. Francis, also those of the Ottawa valley as far west as Mattawa, limiting my observations on the north and south by the higher grounds which border these valleys. In following out these instructions, I began work in the Ottawa valley on the 3rd of June and continued it eastward towards Montreal, making that city a centre of operations for some time. From this point my examinations were extended to the hills on both sides and eastward to Three Rivers, Nicolet and Arthabaska. All the railways and a considerable number of the roads were travelled over, while the distribution and character of the different beds were traced out with as much care as time and circumstances would permit. About the middle of July, I made Quebec city my headquarters and continued to work in all directions from this as a centre for some weeks, occasionally however, following railways and roads to other points. Early in August, I received your further instructions in regard to collecting all available information relating to peat mosses, their distribution, extent, depth, the attempts to manufacture fuel or other products therefrom, together with descriptions of processes, etc., with the view of preparing a bulletin on the subject of peat. These last instructions involved to some extent a re-examination of portions of my field in greater detail and caused me to extend my operations down the Lower St. Lawrence valley as far as Rimouski and Ste. Flavie. The accomplishment of this work in the St. Lawrence valley below Quebec, occupied my time till the 5th of September, and the remainder of the month and part of October were devoted to an examination of the surface deposits and peat mosses in the Eastern Townships of Quebec and in eastern Ontario at points often hundreds of miles apart. As a result of this investigation it was found that while there are a large number of

Nature of field operations.

Work in regard to peat mosses.

General character of peat bogs in Quebec.

workable peat bogs in the region visited, in other localities, as, for example, in the counties of Huntingdon, Beauharnois and Chateauguay and further east in Arthabaska and Lotbinière, the mosses are often thin and form merely a veneering upon the sands and clays. Some of the last-mentioned peat areas are under cultivation, while others are covered with a scrubby growth of spruce and tamarack. In this work I was occupied till about the 15th of October. After that date I commenced investigations in the Ottawa valley west of this city, continuing them as far as Mattawa. But first I visited the Perth and Brockville peat works. After that I proceeded to Renfrew, Pembroke and Mattawa and traced, approximately, the limits of the marine Pleistocene beds there. Field work closed on the 26th of October; but on the 14th of November I visited the Newington peat works, then in operation, and saw the whole process of cutting the peat in the bog, preparing the peat-bricks, drying them by superheated air, etc. The work seemed to be done quite conveniently and effectively at this establishment.

Though the summer was very unfavourable, I succeeded in getting over the greater part of the large field assigned me for the season's operations, and in certain places considerable detailed work was accomplished.

The surface deposits occupying the area under consideration, which is known as the great triangular area of flat country lying east of a line drawn from Brockville to Pembroke, with its apex at Quebec or Kamouraska, in the St. Lawrence valley, may be classified as follows, in descending order :— **Classification of surface beds.**

1. Peat bogs and peat-covered plains.
2. Fluviatile and lacustrine sands.
3. Saxicava sand. } Champlain of United States geologists.
4. Leda clay. }
5. Boulder clay.
6. Decomposed rock.

Peat.—The best developed peat bogs occur in eastern Ontario and in that part of the province of Quebec which lies east of Montreal, and especially north-east of Quebec city. The deeper mosses grow where the surface of the ground beneath is more or less uneven. A number of the last mentioned bogs in Quebec are quite large, some of them five or six thousand acres in extent, with a depth of twenty to forty feet. Spasmodic attempts have been made from time to time to work some of the peat bogs referred to, for fuel or moss litter, but they have, so far, resulted in failure, except at Brockville and Newington, already **Peat.**

mentioned. At the latter place a Swedish process is being employed by the Sahlstrom Fuel Syndicate, and briquetted peat fuel is to be produced when the works are completed.

Fluviatile sands with shells.

Fluviatile sands.—The fluviatile and lacustrine sands seem to be found mostly in the mouths of river valleys tributary to the St. Lawrence, and in the lakes or river expansions, also along the St. Lawrence river itself below the mouth of the Richelieu river. They were observed at Sorel, Nicolet, Three Rivers, Victoria Cove and Orleans island. At Sorel and Three Rivers they contain fresh water shells, (*Unio complanatus*, *U. ventricosus*, *U. luteolus*, etc.). Two of the Dominion Government dredges were engaged in excavating a channel on the south side of the St. Lawrence river at Sorel at the time of my visit, and in the material thrown up on the bank, shells were seen to be scattered indiscriminately. A coarse sandy clay from the bottom of the channel was noted, which also contained the same fresh-water shells.

Marine deposits.

Saxicava sand and Leda clay.—These deposits may be said to form a continuous sheet over this part of the St. Lawrence valley, and were described in the Geology of Canada, 1863, pp. 915–928; also in The Canadian Ice Age, pp. 52–72 and by the writer.* In the New England states the name Champlain has been given to these deposits, as they do not seem to be so well defined or have the same sequence there as they have in the province of Quebec, where the sands and clays are generally separated by a clear line of demarkation. The same arrangement of the Leda clay and Saxicava sand, that is, the former beneath and the sands overlying them, holds good throughout the Maritime provinces.

Boulder clay.

Boulder clay.—The boulder clay, or till, of variable thickness, was met with everywhere beneath the marine beds; and, except in the hill country, to the south of the great plain, it forms only a single deposit. In the valleys among the foot-hills of the Notre Dame range, two boulder clays with interstratified sands and gravels occur, and here also we find two kinds of drift, namely, that derived from the range mentioned and that from the Laurentides. On the north side of the St. Lawrence river the drift is mainly from the latter source.

Raised shore lines.

Shore lines or raised beaches.—These are found on both the north and south slopes of the St. Lawrence valley and were identified and briefly described as marine beaches by the writer in 1897. Further measurements of the highest on the south side of the valley were made which serve to confirm the work of former years, and support the con-

* Annual Report, Geol. Surv., Can., Vol. X. (N.S.), 1897, pp. 67-69, J.

clusion that the ancient crystalline rocks sustained a greater uplift in the later Pleistocene and since that time, than did the stratified rocks. The old shore lines rise gradually, though with some irregularity, from an altitude of 345 feet at Ste. Flavie to 750 feet at Ste. Henedine, to 756 feet on the east side of the Chaudière valley, and 845 feet at the head of Beaurivage river. On the flanks of the crystalline rocks further west, the altitude is 865 ft, rising still further west to 885 feet. This highest shore line continues westward at about 890 feet to Danville, beyond which, as far as the International boundary, it is about 865 feet (at Abbotts Corners 864 feet). Below this shore-line, others occur, some of which are well marked. They have been produced during the recession of the sea, for all are supposed to be marine, and they face the open plain of the St. Lawrence valley.

The highest shore line on Kings mountain, near Ottawa, was re-measured and found to be 910 feet above sea-level.

Agricultural character.—The St Lawrence valley or plain has long been settled and under cultivation. Large portions of the land are of excellent quality for farming purposes. Originally the soil must have been of extraordinary fertility, rivalling that of our western prairies. Certain areas are occupied with clay, while others are sandy. In others again a mixture of sand and clay constitutes the soil; or clay below with a thin layer of sand upon it. The clay soils are considered the best, especially those with a slight admixture of sand; but the surface sands, when not too deep, yield good crops. These are, however, always better when resting on a clay subsoil. Generally speaking, it has been found that the clay lands maintain their fertility the longest. In some parts of the valley, hay crops have been raised on land of this kind for a great number of years without any fertilizers being added, and the soil is still in good condition.

Agricultural character.

Much of the land in the St. Lawrence valley is, however, imperfectly cultivated. Several causes have brought about this condition of things. The seigniorial system, which prevailed in central Quebec, accounts to some extent for it there. In other parts of the province the farms have been divided and subdivided among the members of families, generation after generation, till each has only a narrow strip or patch to cultivate, which barely affords its owner a subsistence. Agricultural operations under these and other conditions, which might be enumerated, must be seriously handicapped, to say the least, and it is not surprising that little or no advances are made in improved methods of farming.

Methods of farming.

Geology of Yamaska Mountain.

Mr. G. A. Young.

Yamaska mountain.

As a contribution to petrography, I have, during the past summer, made a study in the field of the rocks of the Yamaska mountain and also prepared a topographical map of the locality. This mountain lies about thirty-five miles due east of Montreal and was known to form one of those isolated hills of related igneous rocks for which Dr. F. D. Adams has proposed the name of Monteregian hills. The horizontal section of Yamaska mountain is nearly oval. The major axis lies in a nearly north and south direction, and is about three miles in length, whilst the minor axis measures about two miles and a half. The hill rises abruptly from the surrounding plain. On the north and south sides the slopes are precipitous, and it is on the northern side that the mountain reaches its greatest elevation of about thirteen hundred feet above the surrounding country or fifteen hundred feet above the sea-level.

Divided by denudation into two ridges.

The agencies of denudation have acted in such a way that the mountain is divided into two ridges, a northern and a southern, and connected through the interior by a line of small, partly separated peaks which are lower than either of the rims. The higher points are thus rudely arranged in the form of the letter H. The mountain is composed of a core of igneous rocks with a collar, averaging about half a mile in breadth, of more or less altered slates and sandstones. Where the elevation is broken down on the east and west slopes, the igneous rocks of the core approach the foot of the mountain very closely; elsewhere the bordering sedimentaries usually form the higher peaks. The line of contact, whilst conforming to the general outline of the mountain, is very irregular.

Nature of rocks.

The sedimentary rocks of the collar are presumably of Upper Cambrian age and on lithological grounds are supposed to belong to the Siliery formation which is composed chiefly of red and green shales or slates and of beds of sandstone. The clay rocks have, under the influence of the igneous intrusion, in most cases become greatly hardened, so that they have resisted the forces of degradation and in their tnrn have served as a shield to the igneous core. The metamorphism seems to have been greatest along the north and south rims, which, roughly speaking, are at right angles to the general strike of the strata. These rocks now lie in an overturned anticlinal, whose axis runs in a northerly direction, to which the major axis of the moun

tain is roughly parallel. The strike of the strata varies somewhat on either side of an average value of about twenty degrees east of north (true). The angle of dip changes rapidly from point to point, indicating local flexures. This folding took place previous to the intrusion of the igneous rocks which seem at this point of weakness to have forced their way up from below to form a volcanic neck such as Dr. Adams has described in the case of the neighbouring Mount Johnson. No evidence was found in the field which pointed to any other origin than that of a volcanic neck which had been developed without sensibly disturbing the surrounding strata.

Mineralogical composition.

The rocks forming this volcanic neck belong to the foyaite-theralite family. Mineralogically they do not differ greatly, but the relative proportions of the several constituents vary widely. Of the minerals composing the rock, feldspar, hornblende and biotite play the chief parts and the feldspars appear to be mainly plagioclase. The presence or absence of nepheline has not yet been definitely determined. The rocks range from syenitic varieties, composed chiefly of feldspars with considerable biotite, through essexite, in which hornblende, more or less completely replaces the biotite; the feldspars at the same time decreasing in amount into finally an extreme type composed almost entirely of hornblende and often containing considerable iron-pyrites. These various types are usually coarse-grained rocks, but at other places they become firmer and porphyritic. The essexite phase sometimes becomes finer in grain along the southern boundary, where it is in contact with the sedimentaries. Those rocks which have been classed as essexites often have flow structures due to the parallel arrangement of the eminently tabular feldspars and sometimes they are also banded. The direction of flow varies quite rapidly. It is sometimes vertical, but more often inclined, and in one locality is horizontal.

Distribution of types.

The distribution of the various types of rocks is fairly regular. The light-colored, feldspathic forms occur as a border along the western and northern sides. In most places it appears to grade into the more basic essexites which occupy the greater part of the mountain, but which, towards the east, pass into a nearly pure hornblende-rock. At one locality on the eastern border, the hornblende-rock passes rapidly into a syenitic type. These different types appeared in the field in the great majority of cases to pass insensibly into one another, but at two localities the syenite was found sharply cutting the essexite. This apparent anomaly may be due to the fact that, as shown by included fragements of the surrounding rocks, the neck appears to have been still in a process of enlargement till the upward movement of the magma was finally arrested. The various types of rocks are thought

to have originated mainly through a process of differentiation which took place in a more deeply buried reservoir. Their present relations are believed to be due to the movements attendant on their upward flow.

Dykes.

A very limited number of dykes was found, usually either a short distance from the contact or just at the border and cutting the sedimentary rocks of the collar. These dykes appear to be of three classes; a very fine-grained, light coloured feldspathic variety, probably a bostonite; a second which appears to be a fine-grained trachytic modification of the syenite; and a third, a very fine-grained, porphyritic form of the essexite. As these dykes were never found cutting one another their relative ages are unknown.

THE COPPER-BEARING ROCKS OF THE EASTERN TOWNSHIPS, QUEBEC.

Mr. John A. Dresser.

Existence of copper long known.

The occurrence of copper in the Eastern Townships has been known at least since 1840. In that year Logan visited Carbuncle mountain at the head of Brompton lake to examine a reputed occurrence of tin ore which, however, proved to be copper. This was two years prior to the establishment of the Geological Survey of which Logan was the first Director. (Life of Sir W. E. Logan, Kt., by B. J. Harrington, Ph. D., Dawson Brothers, Montreal, 1883.)

Since 1847, when the first explorations were made in the Eastern Townships by the Geological Survey, the copper deposits have received attention in several of the Annual Reports. The most important of these are the Reports for 1863 by Sir W. E. Logan, 1866, by James Richardson, and 1888 by Dr. R. W. Ells.

Early development work.

In the early sixties, copper commanded a much higher price than it has reached at any period since, and at that time a large amount of prospecting and considerable development work was done. In the majority of cases, however, there does not seem to have been a very thorough testing of the many copper localities which had then been discovered. A severe and continued depression in the copper markets followed, so that for many years, less attention was given to this as well as to other copper-bearing districts. There has, however, been a steady and consequently a more healthy growth of interest in this class of ore deposits in recent years, owing to some advance in the price of copper, to improved facilities for transportation, to more economical methods of smelting, and to the constantly

growing use of sulphuric acid, of which cupriferous pyrites is an important source. Thus during the past twenty years, the mines of the Eustis Mining Co. at Eustis, and of the G. H. Nichols Chemical Co. at Capelton, have been steadily working, until under able management, they have attained their present large extent and prosperous condition. Other once abandoned properties are also receiving attention in recent years, and it seems likely that under skilful direction and careful management, they may produce successful results in a good many cases.

Copper-bearing rocks of pre-Cambrian age.

A large part of the copper-bearing rocks of the Eastern Townships are shown to be of pre-Cambrian age by the later maps of the Geological Survey. These occupy three different areas, as indicated upon the accompanying sketch-map which is copied from the Survey's geological map of the Eastern Townships.

The western and central areas have produced all the copper yet mined in the Eastern Townships, with the exception of that obtained from the once famous Acton mine and from others farther eastward, which are related to it, in mode of occurrence, and from the Lake Memphramagog district. Throughout these two belts of pre-Cambrian rocks, copper has been found to occur in many places. Richardson gave a list of about four hundred localities in an appendix to the Geological Survey Report of 1866.

Object of recent investigations.

The work of the past two seasons has been done with a view of finding if possible what different conditions may exist in the mode of occurrence of the important and unimportant deposits, where such differences in value are known. The results show that a part of each belt is made up of volcanic rocks, and that all the deposits of any known, or probable importance occur within these volcanic portions. No deposit of any likely value has been recorded in the sedimentary portions which usually flank the volcanic ridges in these pre-Cambrian belts.

Sutton area.

In the Sutton area the volcanic ridge forms a central part, scarcely more than two miles in width at the International boundary line. Pinnacle mountain at St. Armand stands just within its western edge, and the eastern limit is near the line between St. Armand and Sutton, or nearly due north of Richford, Vermont. Continuing northward, the volcanic rocks comprise all the western portion of the pre-Cambrian on the Yamaska river, and retain about the same breadth as on the east side of the St. Francis river. In the Stoke, or Ascot belt of the pre-Cambrian, Stoke mountain, and the area for some miles south-west on the St. Francis river, which includes the hills of Capleton and Eustis, is almost wholly volcanic. In the township of Weedon, near

the head of the St. Francis river, the same rock appears and extends almost to Lake St. Francis.

The Eustis mine.

The ore-bodies have not been observed to form true veins in any instance. In numerous cases they show on surface exposures the ordinary outlines of much flattened lenses conforming to the foliation of the rock. The walls are not well defined and 'horses' and lean ore masses are not infrequent within the larger ore-bodies. The largest examples seen were in the Eustis mine where masses occur which are more than 100 feet in the least dimension. While they generally follow the dip and strike of the foliation, which affords a useful means of tracing these occurrences, at times they also cross the plane of schistosity of the country rock, generally at an oblique angle. They then have more nearly the character of true veins. Such bodies appear to cut the dip, more frequently than the strike, of the enclosing rock. The lenticular bodies also appear to be frequently arranged en échelon, since the lode, when lost is most frequently recovered, not by following through the pinched-out part along the strike, but by driving at right angles to it. The most experienced miners seem pretty well agreed upon the general accuracy of this procedure.

Copper belt of Lake Megantic.

Of the third pre-Cambrian area, that near Lake Megantic, little is yet known in detail. The wooded condition of the country at the time that the south-eastern quarter sheet of the Eastern Townships map was prepared, made it impossible that the area could be delimited at all definitely. As was shown in the Summary Report for 1902, the area is composed of volcanic rock similar in character to those of the other two belts, and these rocks are to some degree at least copper-bearing. The area appears to be a northern extension of the copper-bearing ridge of Berlin Falls and Copperville in New Hampshire. As in Stoke mountain and at Ditton, in the southern part of the Lake Mégantic area, alluvial gold occurs, which in both cases, Dr. Chalmers considers to have been derived from the underlying rock. They probably occur in the vicinity of the more extensive deposits of alluvial gold in the valley of the Chaudière and its tributaries and have a greater extent towards the north-east. This view is further sustained by the fact that still farther to the eastward in Gaspé, many observers, notably Logan, Ells and Low, have reported the occurrence of rocks characterized by chlorite and epidote which have not yet been microscopically examined.

It is probable that such rocks are a continuation or recurrence of these copper-bearing traps, and that the watershed which determines the boundary between the State of Maine and the Province of Quebec

will be found to be a continuous ridge, or succession of ridges of these rocks, perhaps ultimately connected with the copper-bearing rocks of New Brunswick.

Probable extension of this belt.

Both in their mode of occurrence and the character of the country rock the pre-Cambrian copper deposits are evidently similar to those which characterize certain parts of the Appalachian tract from Alabama to Newfoundland. The Sutton belt is the direct northern extension of the Berkshire and Vershire areas of Vermont, and are similar in all essential respects to those of southern Pennsylvania, North Carolina, and the well known deposits of Ducktown, Eastern Tennessee.

Mines of the Acton district.

Two other areas of copper-bearing rocks in the Eastern Townships are those of the Acton district and of the vicinity of Lake Memphremagog. In the Acton district copper occurs in the Sillery and Trenton formations in connection with small intrusions of igneous rocks. The Acton mine, about forty-six miles east of Montreal, is the best known, and for a few years it produced a large amount of high grade copper ore. Smaller mines as Upton, Wickham, St. Pierre de Durham, and Roxton, have produced more or less copper ore. The Upton deposit is further distinguished by the presence of a little native copper. All of these are now closed, but some of them seem likely to be worth reopening. The little work that was formerly done in most of them was of such a character as to save only a small proportion of the ore. The gangue is almost wholly calcite, and hence useful for a flux with the dry ores of the pre-Cambrian rocks. The ores are chalcopyrite, bornite, chalcocite and copper carbonate. They differ somewhat in the different individual deposits.

Lake Memphremagog area.

The townships of Bolton and Potton, to the west of Lake Memphremagog, contain several igneous hills of the general type of Mount Orford, which are intrusive through lower palaeozoic sediments. Where these have cut black Trenton shales, large bodies of pyrrhotite and pyrites and allied ores have frequently been formed. These are probably the largest ore bodies in the Eastern Townships. The Huntingdon mine, the Ives mine, and the Lake Memphremagog mine are the best known. Investigations with a view of discovering the most economic mode of smelting these ores are about to be undertaken at the mining laboratories of McGill University. These larger deposits are worth the most careful attention of those interested in copper mining.

Charlotte County, New Brunswick.

Dr. R. W. Ells.

Former work in Charlotte Co.

The work of the season of 1903 consisted largely of an examination of certain areas in Charlotte county, New Brunswick, with the object of determining more precisely the age of certain groups of rocks, which in the Report for 1870–71 on this district by Messrs. Bailey and Matthew, and later in the published map of this part of the province, issued in 1879–80, were left practically undetermined, though coloured provisionally, owing to the absence of sufficient data to establish their actual horizons. The geology of this part of New Brunswick is complicated by the presence of large areas of intrusive rocks, comprising granites, diabases, gabbros, and felsites, and by the alteration, in consequence, of large masses of slates and sandstones from their ordinary condition into schists and other crystalline rocks which now present many of the features of the pre-Cambrian series.

Assistants.

In this work I was ably assisted by Mr. R. A. A. Johnston of this Department and by Professor Ernest Haycock, of Acadia University, Wolfville, N.S.

Economic minerals.

Special attention was directed to the occurrences of mineral deposits, including the nickel ores in the vicinity of St. Stephen, the copper deposits of Letite and the Western isles, including Adams and Simpsons islands, and to other mineral occurrences such as the galena and iron ores found at several points in the area around the shores of Passamaquoddy bay. The relations and probable value of these were ascertained as far as possible and their geological positions determined.

Examination in Ontario and Quebec.

Early in August, after *working* out the relations and the ages of some of the more important rock-formations in Charlotte county, Mr. Haycock was placed in charge of the field operations in this part of New Brunswick and my own time was devoted to an examination of certain points in connection with the areas now being mapped in eastern Ontario. In addition to this, an examination was made of several important mining areas, both in Ontario and Quebec, including the asbestus and actinolite deposits, the micas and apatites, and the graphite. As regards the asbestus, this was considered of special importance in view of the great developments in this industry in recent years, the mining methods and the character of the output having been greatly changed since the date of the last report on this subject, published by this Department in 1888–89. In this examination, all the asbestus mines now being worked in the province of Quebec, as

well as a number which have suspended operations, owing to various causes, were visited and a large amount of information was obtained from the study of the areas at Thetford, Black Lake, Coleraine, East Broughton, Ireland and Danville in the Eastern Townships, as also from those north of Ottawa. A study was also made of several of the chromic iron mines, in order to ascertain more precisely the mode of occurrence of this mineral. The actinolite mines of Elzevir township, Ont., which have been worked for about twenty years, were also examined and a special report on the asbestus industry in general has been prepared, bringing the work down to the present year.

Materials have also been obtained for reports on mica, graphite and apatite in Ontario and Quebec, which are now among the more important of the mineral resources of these provinces; and the conditions as to the occurrence of these minerals, as shown by a number of new openings, have been further studied.

GEOLOGY OF CHARLOTTE COUNTY.

The Perry group.

One of the most interesting of the geological formations which occur in this portion of New Brunswick is that known as the Perry sandstone group. The formation receives its name from the town of Perry, in the state of Maine, on the west side of the St. Croix river, whence it extends across the boundary and forms a large area to the north of St. Andrews and continues eastward to Beaver harbour, beyond the shores of Passamaquoddy bay. It again reappears in this direction around the shores of Lepreau harbour and has here quite an extensive development. The rocks consist of conglomerates, sandstones and shales, generally reddish in colour, but occasionally, in the lower portion, some of the heavier sandstones and conglomerates become grayish. Plant stems are quite abundant in some of the shale beds, both in the rocks of Perry and near St. Andrews. These were carefully studied many years ago by Sir William Dawson and several papers relating to their character and age were published by him between 1861 and 1870, in which their horizon was placed as the upper portion of the Devonian system. The same conclusion had been reached at an earlier date by Dr. Jackson, and adopted by Prof. Rogers, after an examination of the material from the plant beds of Perry, Maine.

Probable Devonian age.

In the report by Bailey and Matthew, 1870-71, the opinion is expressed that the rocks of this group are referrable to the base of the Lower Carboniferous, rather than to the Devonian, from a supposed lithological resemblance to certain conglomerates which are found in Kennebeccasis bay, an arm of the St. John river, where these rocks are assigned to the Carboniferous horizon.

In Charlotte county, the Perry group can be well studied in the peninsula extending from the base of the Chamcook mountain to the point at St. Andrews where the exposures are practically continuous for a distance of about five miles. The beds are cut across by several dykes of green diabase which have altered the sediments at their contact. Similar dykes are seen on Ministers island to the east.

Perry conglomerates.

The lowest beds of the group at Chamcook mountain consist of a coarse, heavy conglomerate with pebbles, often of large size, for the most part derived from the felsitic rock of which the mountain is composed. These conglomerates are a conspicuous feature in many places at the base of this series of rocks, and they also occur occasionally as intermediate beds higher up in the series. They are well exposed in the bluff east of Chamcook harbour, on the islands and on the shore at the entrance to Digdeguash harbour and further east on Bliss island, L'Etang head and Pea point and again around the shores of Lepreau harbour, which is in the extreme eastern part of the county.

Thickness of formation.

The dip of the strata in the St. Andrews peninsula is uniformly to the south or south-east, at angles from 10 to 25 degrees. At an average inclination of 15 degrees over a distance of five miles, since the southern margin of the basin is not here reached, the thickness for the beds at this place will be not far from 7,000 feet. No well-defined faults or repetitions of the strata are seen in this section. This estimate of thickness far exceeds that hitherto made for any portion of the lower Carboniferous as developed in southern New Brunswick.

Trap dykes.

In the dykes, no characteristic zeolites have been found, but small deposits of quartz crystals and bunches of calcite occasionally occur. The dykes are sometimes in the form of interbedded masses but sometimes they cut directly across the sandstones.

Thickness of the conglomerate.

The outlines of this formation were carefully traced along the shores from the St. Croix river to Point Lepreau, and in some places, as at Pea point and L'Etang head, the basal conglomerate was found to have a great thickness, aggregating not far from 4,000 feet. At Lepreau harbour, where these rocks are well exposed, they apparently rest directly and conformably upon the Devonian shales and sandstones of the Mispec and Little river groups of the St. John Devonian basin. As they elsewhere underlie the basal beds of the lower Carboniferous, including the marine limestones of that series, it would now appear that the rocks of the Perry group, as a whole, represent the upper portion of the Devonian system of southern New Brunswick, as was early suggested by Sir William Dawson and others from the evidence of the

contained plants. The complete details of their distribution cannot be given in a brief summary report.

Another group of rocks which required careful examination is the series of slates, schists, eruptives, and crystalline limestones which occur on Letite and Frye island, and thence south-westerly through the group of islands including Deer, Campobello, Grand Manan, and many other smaller ones which are a part of a somewhat extensive chain trending in this direction. Much doubt has been felt as to the age of these rocks, and they have been classed at different times as possibly Silurian, Primordial and even pre-Cambrian, and on the published map of the area, they were coloured provisionally as the latter. This determination was based on the presence of certain schists, associated with altered slates, diorites, felsites and other crystallines, the general aspect of which was like many of the rocks east of St. John, included in the Kingston group, these having been regarded as of Huronian age, since they, in part at least, underlie rocks which hold primordial fossils. **Rock of Letite.**

A careful examination of the Charlotte county rocks, however, showed that the so-called pre-Cambrian schists are merely altered slates which have been acted on by newer intrusives and affected by pressure, by which the schistosity has been developed. In places, the slaty schists reveal the presence of fossils in certain layers, in which also the schistose structure is developed and the fossil forms are drawn out along the schist planes. In this respect they closely resemble Silurian and Devonian fossils which occur in the vicinity of Memphremagog lake in southern Quebec. **Fossils.**

The shearing has also developed a schistose structure in certain of the intrusive dykes, so as to impart to these the aspect of pre-Cambrian schists ; but from the fact that most of these intrusives are frequently seen to cut the fossiliferous Silurian strata, it must be assumed that they are newer than the rocks which they penetrate. In fact, at the close of the Silurian and even in Devonian times, there has been, without doubt, a very extensive period of intrusion, faulting and metamorphism throughout all the area in southern Charlotte county. On this basis, much of the area which, in the published map, was coloured as pre-Cambrian must now in part be assigned either to the upper Silurian and Devonian, or indicated as a newer eruptive series. **Schistose structure.**

Large collections of fossils were made from a number of points, including the upper part of Oak bay, the Mascarene shore, especially about the entrance to the broad inlet of the Magaguadavic river, on Fryes island, Letite and elsewhere. These collections have not yet

been fully determined, but sufficient has been learned from them to show that their general aspect is characteristic of the upper portion of the Silurian.

Mascarene series.

Of the peculiar group of rocks which have been described under the name Mascarene series, it may be said that they consist of a considerable thickness of purple slates and sandstones with green and gray beds, the latter predominating, which have been cut by numerous intrusives, both diabases and felsites. The action of these on the sediments is quite clear as they have altered the strata in contact at many points. The felsites, which are generally reddish, sometimes occur as great bedded sheets. In position, the Mascarene rocks may be said to be intermediate between the Silurian of Letite and Back bay and the base of the Perry sandstone group. The presence of well defined plant stems in some of the strata of Mascarene tends to place them also in the Devonian.

The Western isles.

The rocks of the Western isles, including Deer and Campobello and many smaller ones lying in their vicinity, were all examined. For the most part, they consist of newer intrusives, comprising diabase, gabbro, felsites, and some granite, and with these are occasionally found areas of altered slates, now sometimes changed to schists, similar in character to those of Letite and showing, in places, the traces of fossils. There is no reasonable doubt that the rocks of the greater number of these islands must be referred to the Silurian or to the later intrusives. Some of the smaller islands to the east of Deer island show conglomerates of the Perry group and represent the extension of the broad development of these rocks which compose Bliss island and the shores of the east side of L'Etang harbour. There are no reasons apparent why the rocks of these islands should be coloured as pre-Cambrian.

Crystalline limestone of Fryes island.

The interesting band of crystalline limestone which occurs on Fryes island, and which, after crossing from the south to the north extends across the passage to L'Etang peninsula, and appears in a broad belt just west of L'Etang village, was carefully examined. It has been regarded as representing the crystalline limestones of the Laurentian, as developed about St. John, but from the fact that it is closely associated with slates, now schistose, of Silurian age, and in places contains fossil corals and other forms at several points, the geological position formerly assigned to it must now also be changed. The crystalline limestones show several stages of alteration, and in places where the alteration has not been so complete, an abundance of fossil shells with corals was found. The highly crystalline portion gradually shades off into bluish and less altered limestone, and the peculiar green and

Silurian age.

purple shales and sandstones of Silurian age are clearly a part of the

limestone series. They do not resemble the crystalline limestones of Ontario and Quebec in their association with gneisses or quartzites, but rather the metamorphic limestones of Memphremagog lake and of Dudswell in Quebec, concerning the Devonian and Silurian age of which there is now no question. Even in the most highly altered portion of the limestones, there are indications of corals which have been flattened out by pressure and now conform with the general schistose condition of these sediments. Small deposits of galena, with fluor spar, are seen in connection with these rocks on Fryes island and a slight attempt was made many years ago to open these by mining. The quantity is, however, too small to be of much economic value, and no work in this direction has been attempted for a considerable time.

Eruptives.

The broad belt of rocks, coloured as Silurian on the published map, extending along the shore from the St. Croix to St. George, will of necessity be represented in greatly reduced area. In a section along the railway north from Chamcook, where good rock-cuttings are exposed almost continuously for some miles, the rocks of this division are clearly eruptive, consisting of diabase, gabbro, granite and red felsite, all of which are newer than Silurian, and in part at least, later in date than the Mascarene series. There is no reason why these rocks should be included in a general Silurian colour scheme. They comprise a large portion of what, in earlier reports, were described as bedded felsites, the intrusive character of which is manifest upon close examination.

Surveys.

Surveys were made of all roads over a great portion of the country, but time did not permit the completion of this work during the season. Further detailed examinations will also be required to settle definitely the exact horizons of some of the slate belts, including that to the north and east of St. Stephen, and it is hoped that a close search will reveal the presence of fossils in some of the less altered beds. The fact that such fossils were found during the past season in most unpromising localities leads to the expectation that this hope will be realized and the actual horizon of some of these now doubtful beds will be ascertained.

Rocks of Beaver harbour.

About Beaver harbour an interesting series of slates and conglomerates, with shales, occurs. These are associated, in part, with the usual masses of intrusives of later age, portions of these occurring as bedded flows. The shales are often plant-bearing, and are referable to the Devonian, and a portion of the intrusive rocks are intermediate between these plant beds and the base of the Perry conglomerate seen at Pea point, Blacks harbour and Deadmans point. In part, these intrusives are basic, while other portions are acid rocks, largely red

felsites. The latter frequently occur at the base of the conglomerates, both at this place and about Passamaquoddy bay.

Beaver harbour to Lepreau.

From Beaver harbour, east to Lepreau, the shore section shows a series of eruptive rocks, consisting largely of granites and felsites. The associated rocks are generally schistose, and the actual age of these was not determined, though they may represent portions of the slaty series of Letite, altered by intrus'ves and pressure, as further west.

Lepreau harbour.

At Lepreau harbour the lowest beds of the Perry conglomerate rest conformably upon the recognized Devonian of that area, which in character and from their contained plants are precisely similar to the St. John Devonian as represented by the "Fern ledges." These contain an irregular bed of graphitized coal, partly anthracitic, which has been described in earlier reports (1878) as occurring on the north side of Belas basin. A large amount of work was spent on this deposit about 25 years ago, but operations were suspended shortly afterwards.

In the northern portion of the county our field-work has not yet been finished. The plant-bearing formation, in so far as examined, is practically as outlined on the published map, being probably of Devonian age, but further work is necessary to complete details of distribution.

Copper ore of Letite, &c.

The copper deposits of Adams and Simpsons islands and of Letite were examined by Mr. Johnston. The conclusions arrived at seem to indicate that while small quantities of rich ore are found at several of these places, the quantity is not sufficient to warrant any great outlay on permanent works. The occurrences are usually small and irregular in their distribution. A large amount of exploratory work appears to have been done at different intervals, but apparently without profitable results. At Letite, several shafts were sunk about 40 years ago on belts of gabbro and diabase which cut Silurian slates, and some chalcopyrite and copper-glance, mixed with pyrrhotite were found; and recently another shaft has been sunk to a depth of about 140 feet, from which good specimens of chalcopyrite are also obtained. As the shaft was filled with water at the time of our visit, the actual condition below the surface could not be ascertained.

Granite quarries.

The granite quarries in the vicinity of St. George still continue to be worked at intervals. A very full description of these is given in the recent report of Dr. Bailey on the "Mineral Resources of New Brunswick," Vol. X, 1897, pp. 102-106.

Nickel bearing rocks of St. Stephen.

The nickel-bearing rocks of St. Stephen was specially examined and found to consist of newer intrusives, instead of the Laurentian granites,

as at one time supposed. The rocks are chiefly of the gabbro type which have penetrated and altered a series of black and gray slates, the age of which has also been a matter of much doubt. They were at one time supposed to be of Silurian age, but from the absence of fossils, this point has never been fully determined. As developed about the head of Oak bay, it was also supposed that here they might be the equivalents of some portion of the primordial of the St. John area, but this point also has never been determined by finding fossils. On the geological map of the district they are provisionally coloured Cambro-Silurian. They apparently underlie conformably the sandy slates which are regarded as Devonian and which occupy the north-west portion of the county, and on this basis, their age might well be Upper Silurian.

Altered slates.

They are extensively altered in many places, changing into mica and chiastolite schists, but these alterations are purely local and caused by intrusions of the gabbro masses. They resemble, in certain points, pre-Cambrian schists, but not as a series. Further detailed examinations for fossils will be required to finally settle the question of their true horizon.

Occurrence of nickel ore.

The nickel near St. Stephen occurs in pyrrhotite, as at Sudbury, but the associated rocks are of a very different geological horizon from those of the latter district. The pyrrhotite is found in gabbro masses which cut a series of slates and have altered these extensively along the contacts. The mineral occurs apparently in pockety masses which are probably quite local in character. The ore is found at a number of points, but attempts at mining for nickel have been made chiefly at two places, on what are known as the Rogers and Hall farms. The former is usually styled the Todd mine, the latter the Carroll mine.

The Todd mine.

On the Rogers farm, considerable work, mostly of an exploratory nature, has been done. A shaft 12 x 12 feet has been sunk for 24 feet, and three trenches have been cut, with depths ranging from three to eight feet, the principal one being rather more than two chains in length on a course of S. 54° W., magnetic. In this trench, the ore is exposed for a little more than 30 feet along the line of the excavation, the rest of the cut showing partly mixed ore and partly rock. The width of the ore-body was not ascertained, as sufficient development work has not been done to decide this point.

Carroll mine.

On Hall's lot (Carroll mine) several shafts have been sunk, one of 77 feet, one of 14 feet and one of 12 feet. In addition, a bore-hole with a diamond drill was carried down from the bottom of the deepest

shaft to a further depth of 163 feet. From information obtained from Mr. J. Carroll, the first 40 feet of the main shaft was in ore, but from that point to the bottom, the ore was mixed with rock. The log of the boring shows as under :—

Section of bore and shaft.

	Feet.
Hard rock, dark gray	17
Ore, white	1
Hard rock, black.	19
Rock and ore, mixed	7
Sandstone and ore	2
Ore, white	16
Hard rock, dark gray	6
Ore, steel gray	7
Rock, soft	12
	163

The formations at this place are practically the same as on the Todd area. The openings are apparently near the eastern edge of the gabbro mass, since altered slates are seen in close proximity.

A number of assays have been made from time to time of the ore from this locality. As there is apparently but little difference in the character of the ore from the two locations, these may be here given as fairly representing the quality as regards nickel contents.

Assays of nickel ore.

From the Carroll mine, an assay by Ricketts and Banks of New York city, from a sample of the core at a depth of 128 feet gave:

Nickel, per cent	2·42

Another by Ledoux and Company of New York, sample of boring from a depth of 128 feet gave :

Nickel	2·18
Cobalt	·15

An assay by Mr. R. A. A. Johnston of the Geological Survey laboratory gave :

Nickel	1·72
Cobalt	·16
Copper	·31

An analysis by Mr. W. F. Best of St. John, N.B., from the Carroll mine gave :

Nickel	2·62
Copper	7·92

An assay of ore from the Todd mine by the school of Technology, Boston, gave (See Report, 1890-91) nickel 1·92, and another from the trench gave 1·97.

Assays of ore from the bank of the St. Croix near Milltown, by the State Assayer, Boston, gave nickel, 1.10, and by the Geological Survey, from the Thompson Farm, ·923, with cobalt ·394 (See Report 1880-81-82, p. 16H).

Assays by Mr. Connor of this Department from specimens selected by Mr. R. A. A. Johnston, during the present season, from both the Todd and Carroll properties, gave nickel, 1·38, cobalt, 0·21, for the Todd mine, and for the Carroll mine, nickel, 1·35, cobalt, 0·21.

It will be seen from all these assays that the percentage of nickel in the pyrrhotite is practically too low to permit the ore to be smelted after the manner of those of Sudbury. If a process of concentration could be installed on the spot at an expense not too heavy, it is possible that a paying industry could be thus established, the resulting concentrates being shipped to the larger works at Constable Hook in New Jersey, where the final separation and refining could be completed.

Character of rocks and ore bodies.

The rocks at all these places appear to be very similar in character, and consist, for the most part of a gabbro, varying from fine to somewhat coarse-grained. The presence of the pyrrhotite is indicated by masses of gossan at the surface, and in places, the ore is largely mixed with rock. There does not appear to be any well defined contact of the ore-body with the adjacent rock, and but little indication of a vein-structure is visible. Outside of the ground covered by the trenches and pits, the surface shows the gossan cap at a number of points with a thickness ranging from a few inches to several feet. From the fact that this capping shows at several places, east of the main trench on the Rogers farm, it is probable that masses of pyrrhotite will be found over a considerable area, but probably in many cases so mixed with rock that careful separation would be necessary after mining. The existence of these ore-bodies could be best proved by judicious boring with a diamond drill. The areas of gabbro are limited and appear to rise in dome-shaped masses through the slate formation at a number of places. In the present state of development of the district, but little information of a definite nature can be given as to future values.

Nickel at Moore mill.

At the location near Moore's mill, while the gabbro is seen at different points, pyrrhotite appears to be disseminated in a mass of altered schistose slates. The ore here is apparently also of low grade and the extent of the deposit not large.

Grand Manan.

Time did not permit of an examination of the island of Grand Manan, but from previous reports by Verrill, Bailey and others, it would appear that the rocks are, as a whole, somewhat similar to those seen on Deer and Campobello islands. There are large masses of the newer intrusives, which have altered the slates of the Letite and Fryes island type into schists. The rocks on the west side of the island are of a different class, resembling the diabases of the upper part of the Bay of Fundy. A more detailed examination of this interesting area will be necessary.

Northern Part of Nova Scotia.

Mr. Hugh Fletcher.

Winter office work.

Mr. Fletcher spent the winter of 1902–03 in compiling the surveys of previous years enumerated in the Summary Report for 1902, pp. 388 to 399, in giving advice personally and by letter to miners and explorers in certain districts of Nova Scotia, and in studying the new and important extension and correction of former explorations in the light of results obtained by the government drills and otherwise, in their bearing on obscure points in the geology. Records of the exact position of all these boreholes and of the strata cut by them should be carefully kept.

Assistants.

Mr. Fletcher was assisted during a portion of the winter by Mr. J. A. Robert, B. Ap. Sc. and Mr. M. H. McLeod, and during the whole season by Mr. A. T. McKinnon.

Field work in Cumberland, Hants, Kings and Annapolis.

Leaving Ottawa on June 16 for field-work in Nova Scotia, he was employed for the most part in Cumberland county until the end of the year. Mr. McLeod worked in conjunction with Mr. Faribault and his assistants in the district north and west of St. Margarets bay and from the Ponhook lakes to New Ross, in the counties of Halifax, Hants and Lunenburg; while Mr. McKinnon was occupied with a survey of roads necessary for the construction of a map of that portion of Kings and Annapolis counties lying north and south of the Dominion Atlantic railway, between the Hants county line and Lawrencetown, most of the streams having been already surveyed. Mr. McKinnon also made supplementary surveys on the Blomidon peninsula for sheet 83, which is now ready for publication, and, at the close of the field-season, procured a quantity of various minerals for educational collections in Hants and Pictou counties.

The borehole at Hantsport* was given up at a depth of about 1,500 feet, the rocks cut being still similar to those near the top, but gray sandstone predominating.

Boreholes at Hantsport, New Glasgow and Cheverie.

That on the East river, Pictou* was lost and another begun with a cable-drill at the same place, which has reached a depth of 1,900 feet and is still in the New Glasgow conglomerate.

The borehole at Cheverie* was abandoned at 1,910 feet. It was ten inches in diameter at the top, eight inches at the bottom, cased to 1,836 feet and reamed to 1,910 feet. The following section is given by Mr. C. S. Gayton, who is in charge.

		Feet.
1.	Surface and drift	20
2.	Dark gray shales	30
3.	Shale and gypsum mixed in streaks	150
4.	White gypsum	370
5.	Red shale	80
6.	Light-gray shale	10
7.	Red shale	240
8.	Red and gray shale in alternate layers	100
9.	Gray sandstone, with a flow of salt water	20
10.	Light gray shale, with a little sandstone	200
11.	Red and gray shales mixed	50
12.	Shales with gypsum	130
13.	Whitish quartzose sandstone, very gritty	350
14.	Dark gray shale	60
15.	Dark-gray sandstone. A flow of salt water not so strong as the last	30
16.	Dark-gray shale	50
17.	Whitish gray sandstone, with a great flow of salt water	20
	Total	1,910

No sign of petroleum was found. It is to be regretted that the dip of the rocks at this borehole was not taken.

In Cumberland county the work of last season consisted only of a more precise definition of lines laid down by Professor H. Y. Hind, Messrs. Scott Barlow, Walter McOuat, Dr. Ells and others, and reproduced in the maps and reports of the Geological Survey, references to which are given on the map of the Springhill coal-field (No. 812). A

*Sum. Rep. for 1902, p. 391.

problem of great commercial and industrial importance here involved is similar to that discussed by Dr. Poole and Dr. Ells in regard to the existence of beds of workable or accessible coal beneath overlying strata in Prince Edward Island and New Brunswick, and has already been referred to.* On the strength of evidence collected as to the possibility of its existence, a borehole has been begun at the head of tidewater in the large brook at Spicers cove and another on the west side of River Hebert, a mile below the outlet of Fullerton lake. The results of this experiment will be watched with interest for, apart from the distance of this field from the coal mines at present worked, the depth to which boring must in any case be carried, and the difficulty of cutting conglomerate, the basal rock of the upper series, there must be added the uncertainty in regard to the thinning out of the workable coals in some directions, their deterioration, as on the north side of the basin, at the Joggins and elsewhere, and the chance that some or all of the strata underlying, as at Pugwash and River Philip, may be lower than the coal measures. The great belt of gray sandstone and clay shale in which lie the coal seams is of variable composition in different parts of the field, particularly as to the size of the coal-seams.

At Spicers cove.

The hole at Spicers cove, bored by Messrs. J. A. Johnson, B. F. Pearson and others with one of the government calyx drills (No. 5) is now down about 650 feet.† It began near the horizon of the small seams of coal exposed on the shore, but soon passed into a conglomerate containing large pebbles of red granite and other igneous and metamorphic rocks in a fine or coarse matrix, resembling in colour certain Triassic beds of the Bay of Fundy and including small basins of clay-shale with pockets of coal.‡

Atkinson brook.

Current reports of discoveries of coal on Atkinson brook, a branch of River Hebert and other places in the neighbourhood of the second borehole were found to be entirely without foundation; and there is no evidence that workable coal comes to the surface at any point on the southern edge of this trough. The borehole at Fullerton lake is now about 1300 feet deep.§ These two boreholes are in a basin tilted gently westward from the coal measures, millstone grit and Carboniferous limestone of the Springhill coal-field. To the eastward of it the lower strata extend, as shown on the map of 1885, to the neigh-

* Vol. XV., 1902, Part A, pp. 367, 377 and 395. On page 395 for 1,500 read 15,000.

† April 11, 1904.

‡ Sum. Rep. for 1892, pp. 41 and 42; for 1897, p. 100; for 1902, p. 378. Nova Scotian, Oct. 1903. Dawson's Acadian Geology, 'General Section Minudie to Apple River,' page 150.

§ April 15, 1904.

hourhood of Thompson station, where another basin of Permian rocks overlies and extends to the Pictou coal-field. This structure again suggests the question * whether parts of this second basin also may not be underlaid by workable coals, more particularly since, at Pollys brook and Oxford Junction, certain small coal-seams of the lower part of the Springhill section reappear in the eastern basin, the common axis of the two basins tilted west and east respectively, following the valley of Pollys brook for some miles among conglomerates which underlie the coal measures in nearly horizontal attitude. The gypsum of Salt-springs, Clairmont, and the belt northeastward to River Philip above Oxford, thence eastward to Birchwood, Hansford and Victoria, is clearly Lower Carboniferous, and that of Hartford, East Wallace (Plaster Cove) and Malagash Point is on the same anticlinal line,† an extension of the Clairmont anticline, the position of which is well marked along the shore. The limestones, red and green marls and flags of Johnston brook and the north side of Clairmont form part of the same formation; while to the northward they are in contact with Upper Carboniferous rocks from Glenville to Oxford, marking the line of the Black river fault which is well shown at the mouth of the little brook from McManaman's and also on the north side of Black river at the bridge near Richard Keiver's; the rocks at the latter point, on the south side of the fault, being, however, coal measures.

Lowest coals of the Springhill section.

Lower Carboniferous rocks.

Gypsum.

At Goose Point on River Philip, a fault seems also to separate the Permian from the Lower Carboniferous, the latter then spreading out in Roslin on another anticline, probably that which brings up also the gypsum and limestone of Canfield creek. These rocks apparently occur as outliers surrounded by Permian red marls and sandstones with layers of gray and greenish-gray crumbly sandstone, blackened with carbonized plants, stained green, and carrying trunks of trees converted into a mixture of coal, chalcocite and pyrite. The broken land of Canfield creek affords a fine display of 'plaster pits.'

The gypsum of Plaster cove seems to be on the north side of a fault passing clear of Macfarlane point. That of Blue Sea corner is succeeded to the westward on the shore by gray and rusty sandstone, containing drifted trunks of trees, coal-pipes several inches in diameter, traces of pyrite, chalcocite and galena, of black crystalline ironstone, calcareous 'bull-eyes' and masses of gray concretionary limestone-conglomerate.

The banks of red clay-marl dug for the use of the brick-works at Pugwash, broken land and a long ledge of limestone indicate the

Brick-clay and limestone quarries of Pugwash.

*Professor Hind's paper in the Nova Scotian, Oct., 1903, page 30.
† Report for 1885, Part E, page 40.

Lower Carboniferous on the west side of Pugwash harbour. This limestone is whitish and gray, nodular and compact, dips N. 58°E. < 73°, but is slightly contorted, in massive beds of considerable thickness, of an aggregate section of 150 feet. It has been quarried for some distance along the strike for shipment to Prince Edward island. The gypsum of River Philip and Hansford contains fine plates of selenite.

Collingwood and Westchester.

By reference to the Springhill map, it will be seen that the conglomerate of Pollys brook, which underlies the coal seams, extends through Windham to Davison brook, at the head of which it rests upon the pre-Carboniferous rocks of the Cobequid hills. In the east branch of Davison brook, however, there is interposed a narrow belt of light gray, greenish-gray and rusty, fine, sandy flags and coarse grits, full of carbonized plants and threads of coal, interstratified with layers of red shale and sandstone and patches of concretionary, vesicular limestone-conglomerate, which extends from Collingwood corner up along the east branch of River Philip, through Westchester station to Wentworth and East New Annan. This series resembles that of the Glenville and River Philip quarries and certain rocks in the neighbourhood of Streets ridge; it everywhere underlies a conglomerate, but whether the latter is all of the same period of formation may be doubted.

Basin of the lowest seams.

There is apparently an unbroken belt of conglomerate down River Philip from Collingwood and Windham to Pollys brook and also eastward to Millvale and Westchester valley, overlaid to the northward by gray sandstone and grit, as on the south branch of Black river, and at the mouth of Tillet creek by reddish marls, whitish nodular sandstone and grit and rusty pebbly grit and conglomerate with a low southerly dip. An opposite dip, also low, is found among these rocks in the brooks crossing the old Westchester road between River Philip and Millvale, while the northern edge of the basin is indicated by outcrops on the Jungle road and the Intercolonial railway from Oxford Junction to Thompson. Eastward from these points they run across the Colonel's brook and the Emery Meadow brook, but before reaching Atkinson siding appear to pass beneath conglomerate and reddish and blackish soft crumbly shales, like those which overlie the coal measures between Springhill and Athol.

At Thompson.

This gray sandstone series, as already stated, includes the coal seams exploited on Pollys brook and about a mile east of Oxford junction.* These latter extend to Thompson among the gray sandstones exposed

* Depart. of Mines for N. S., 1893, page 6.

in the railway cuttings and bored by Mr. Thomas Matheson. The coal seam of Pollys brook consists of three inches of coal in a band of clay shale and underclay about six feet thick, underlaid in the brook by rusty conglomerate and grit, exposed for a considerable distance with a very low dip in flat undulations down stream towards the head of the millpond.

Below the Emery meadow there are obscure outcrops of gray sandstone. About one-eighth of a mile above the confluence of Emery brook, an excavation made by a Halifax company in the Colonel's brook disclosed, according to Mr. George Purdy, six inches of black coaly shale, included among greenish and gray clay-shales underlaid by a quantity of red shale. Between this point and Mr. Purdy's house, many large blocks of gray sandstone are found, while north-west of the road at his house, similar sandstone, in part massive and of fine texture, has been somewhat largely quarried in the Mile brook. Below the confluence of the Emery brook, gray fine sandstone, of good quarry texture and grindstone grit, is also exposed with a low dip.

From Pollys brook, the axis of the basin of which these rocks form the south side, passing half a mile south of Thompson, through Lower Wentworth, Brulé harbour and John bay, enters the sea three miles east of Cape John, the highest rocks in the field being underlaid east of Brulé by strata having a low dip to the westward. On the north side of this basin, rocks of the gray sandstone series keep along Big lake, through Kerr's and Howard's mills and north of Dewar river to Malagash point, where they contain small coal seams and were recognized as "very like the lower part of the coal measures by Sir J. William Dawson* who also remarks that unless the more important parts are concealed by the imperfection of the sections, the whole Carboniferous series appears here to be less fully developed than on the western coast of the county." It is on the assumption that this imperfection may be due to unconformity and to the overlapping† of the coal measures by higher rocks that deep boring for the discovery of the coals is suggested in this basin also. If no such unconformity exist, the strata of the basin south of Big lake, Dewar lake and Tatamagouche bay must represent the coal measures of other districts barren of coal. As having a bearing on this question, a close examination should be made of the rocks west of River Philip between Kolbeck and the Stanley mines, beyond the limit of the present map sheets, where the coals of the Joggins section appear to thin out or disappear.

At Malagash.

Boring suggested.

* Acadian Geology, page 216.
† Report for 1885, Part E, page 42.

Big Lake coal mine.

From the Lower Carboniferous rocks of Hansford and Birchwood the outlet of Big lake affords a fine ascending section to those of South Victoria and Streets ridge. The Big Lake coal mine, so called, is of great scientific interest, if of little commercial value. Here, with a small engine for hoisting and pumping, two slopes, about 280 feet apart, have been sunk about 60 feet S. 21° E. < 50° on the dip of two belts of dark-gray clay-shale, full of fossil plants, trunks of trees and *Stigmaria*, with pipes and thin layers of coal, the largest not exceeding eight inches. The band farthest south is associated with balls or masses of flinty grit; in the other, both roof and pavement are regular and the band of gray shale and sandy flags is twenty feet in thickness. Gray Carboniferous strata also prevail to the northward, while immediately south of the mine lie red sandstone, grit and conglomerate of the higher series, provisionally called Permian, the change being so abrupt that unconformity seems probable. A similar unconformity seems to separate the gray sandstones of Thompson from the red marly shales and flags, grit and conglomerate of the Intercolonial railway between Thompson and Atkinson. The latter extend northward through New Jersey and occupy the country from Greenville to Streets ridge, borings made at intervals across this tract having shown only these red strata and confirmed the evidence of the natural exposures.

Westchester valley.

Up the brook south of Atkinson siding, conglomerate is well exposed in cliffs, and a small quantity of barite in highly crystalline aggregations has been dug from irregular veins and masses in it. At Westchester valley, up the main river, a pit dug in gray and rusty sandstone of the lower series shows many carbonized plants and a streak of coal associated with sulphides, principally pyrite.

Conn's mills.

The conglomerate of Pugwash river above Conn's mills succeeds the black shales of Hansford siding and Roslin, but is perhaps Permian. As there are conglomerates at the base of the three series of Lower Carboniferous, Millstone Grit and Permian rocks, great care must be taken to distinguish between them, and it is possible that with every precaution, mistakes will be made in their identification. Much of the land of Pugwash harbour and Port Philip is low and shows few exposures, but those along the outer shore are good. Southeast of the brick-clay deposit is a small quantity of coaly shale and a *Stigmaria* underclay, underlaid by gray and rusty sandstone and flags with patches of greenish-gray limestone-conglomerate and grit, but no workable coal. A little farther south, on Chisholm creek, gray and blackish sandstones and flags yield a large quantity of excellent chalcocite, specimens of which were shown at a recent exhibition in

Halifax as a good type of this class of ores, fully described in previous reports.

Copper ore of Pugwash.

Intermittent attempts are still made at Wentworth Centre* to mine and reduce these ores by a process similar to that in use at Dorchester, New Brunswick, but the prospects of success do not seem to have improved.† Northwest of the limestone quarry, several pits have been sunk to test the bog iron ore found near the surface in that vicinity.

Not far below Kerr's mills, nearly vertical beds of light-gray and rusty conglomerate containing coal-pipes, pyrite and chalcocite rest against red shales and interstratified thick beds of gray sandstone. The quarry sandstones of Wallace bridge seem also to underlie this conglomerate, and these in turn are the sandstones of Wallace harbour.‡ A section of the rocks from Kerr's mills up Wallace river to the head of Howard's millpond, has been prepared in more detail than that given in Dr. Ells' report, and certain bands have been traced across the country; but the results will not be here presented. Gray sandstones are well exposed also on the roads from Malagash station to Wallace ridge, thence to the Stake road and to a considerable distance east of it; they resemble those of the Wallace quarries, Howard's mills and Wallace bridge.

Wallace quarries.

As already pointed out, the north side of this basin is characterized by steep dips and faults, and the bottom of the basin is seldom far from the northern boundary of what have been regarded as the overlying or Permian rocks. On the south side, from the axis to the foot of the Pre-carboniferous hills, the basin is broad and the dips low; this would therefore, probably, be the best side to bore for possible coal measures, if the latter are not too deeply buried beneath the Permian.

The rocks of the Wallace river section differ considerably from those of Maccan river between Athol and Southampton, the latter being for the most part finer in texture, like those along the Upper Maccan river and Rattling brook. Those of the East brook are similar and towards the old Mountain road they include beds of conglomerate.

Wallace river section.

Explorations have been made to a small extent, partly in the Lower Carboniferous and partly in the adjoining gray sandstone, northwest of Stewart meadow, by Mr. Thomas Pigott and others, in search of an extension of the Springhill seams; but no discovery of coal has yet been made. A borehole, now about 500 feet deep, on the south side

Explorations near Springhill Junction.

* Sum. Report for 1902, page 396.
† N.S. Depart. of Mines, 1897, p. 50; 1898, pp. 51-52; 1900, pp. 54-55.
‡ Rep. for 1885, Part E., page 40.

of the Intercolonial railway track, at the water-tank immediately east of Springhill Junction, has passed through red marls with a few thin beds of reddish and gray sandstone. The belt of gray sandstone along the railway from Springhill Junction to Saltsprings station, interrupted only by a short exposure of the Lower Carboniferous of Stewart meadow, has led naturally to the supposition that they are continuous as well as on the same horizon.

Upper Maccan river.

Passing now to the south side of the Springhill basin, it will be remarked that the rocks of the Wolf road strongly resemble those of Mapleton and Leamington, the Rattling and Harrison brooks, their general resemblance to those of the south branch of Black river, which underlie the coals, being equally striking. At the house of Mr. Albert Brown, immediately east of the crossing of the east branch of Lawrence (South) brook, a small seam of coal is said to have been cut in a well at a depth of 60 or 70 feet, and coal-wash found north of it on the bank of this brook at a little burying-ground. This would seem to be directly on the strike of the coal cut in the 715-feet borehole at Mapleton* and would suggest the probable extension of this seam to that point

Exploration for coal.

Although many of these details may seem unsuitable for a preliminary report or may have been given before, they are repeated as having a direct bearing on the development of this district and as suggesting certain lines that explorations may follow. Prospecting for coal, like mining, is not a game of chance, but a legitimate venture that should be conducted under honest, competent management, without over-capitalization or appeals to the cupidity of shareholders by fraudulent or ignorant misrepresentations.†

Boring at Leamington and Mapleton.

In the Springhill basin, further explorations were made last summer by two men who bored eighty-four holes, sixty-one feet deep and under, and dug several pits, to define more precisely the position of certain distinctive beds of coal and shale in the district between Mapleton and Rodney.‡ By this means the coal seam traced from the 714-feet borehole was found to turn from the point to which it is drawn on the map of Springhill (No. 812) northward 1,200 feet to a point a few feet past Rattling brook, where it was lost, probably against the fault already proved at Mr. C. E. Corbett's, west of J. W. Hunter's at the old Mountain road. The belt of red shale overlying that seam from Mapleton northeastward is shown on the map. North of this

*Sum. Rep. for 1902, page 394.
† The Nova Scotian, Oct. 1903, pages 33 and 63.
‡ Sum. Rep. for 1902, page 394.

fault a similar belt of red shale overlies the seam bored 700 feet north of Mr. Hunter's and was traced, around the point of the anticline* shown on the map, northward to the fault at the old Mountain road. This coal also was now traced, by boreholes, parallel to the red shale for about 1,500 feet to the point of the anticline, but was not followed on its northwesterly dip nor to the fault, for want of time, Enough was, however, done to prove it the probable equivalent (on the north side of the Corbett fault) of the seam of the deep borehole at Mapleton‡ which it strongly resembles in composition and associated strata. The coal seam represented as probably lying west of this one should, therefore, be erased from the map, as also the suggested connection of the Dan McLeod seams with the coal at the Athol road.

A broad belt of red shale, overlaid by gray and greenish-gray argillaceous shale like the foregoing, was next found on the old Mountain road 800 feet north-west of and overlying the coal traced from Harrison brook† southwestward to that road; so that this seam also, in the absence of any evidence to the contrary, may be regarded as identical with that of the Mapleton deep borehole, as suggested on the engraved map (No. 812). A hole sixty feet deep was bored below the outcrop of the seam at Mr. Herbert Stonehouse's on the Athol road, cutting gray shale and sandstone, the red strata overlying which, begin a short distance west of the house, are well seen at the crossing of the railway and along the latter nearly to the bridge across Harrison brook.

A few feet on the dip of one of the Dan. McLeod pits, west of the Leamington road § a borehole was put down to the coal, which was afterwards traced more than 1,000 feet to the south-eastward of the road, but seems here to be cut off. Little is known of the extension of these coal-seams to the eastward, but they could probably be proved by boring. Much of the surface hereabout is encumbered with large blocks of gray sandstone. From Herritt's old dam (from which a pump now throws a large stream of water through a straight line of pipe to the ponds above the west slope, for the use of the mines) southward, this sandstone is more pebbly as a rule than that on the north side of the river, but not otherwise different, there being apparently in passing south only an increase of conglomerate, with which is associated red marl, and in a little brook, sandstone, grit and argillo-arenaceous rocks, precisely as in the banks of Tom Boss and Sugarwood

Obscurity between Leamington and Rodney.

* Sum. Rep. for 1900, page 163, line 25.
† Sum. Rep. for 1902, page 394.
‡ Sum. Rep. for 1900, page 163, line 23.
§ Sum. Report for 1900, page 163, line 7.

brooks, that nearest Maccan river being dark greenish-gray argilite and fine grit. The cores as described from the 134-feet bore-hole near Tom Boss show apparently an extension of these rocks.

The basin near Rodney nowhere indicates the proximity of a great fault or points to a possible separation of these rocks from those to the northward along a well-defined line; and yet along the line from Tom Boss brook to Mapleton the coal-seams are succeeded by conglomerate, sometimes apparently abruptly; and several small obscure faults have been proved.

Mining at Springhill and other collieries

Mining at Springhill has carried the 2,300 feet level of the west seam northward, approximately parallel with the line of outcrop shown on the survey map (No. 812), across the railway and the East brook, nearly to the Junction road; and a slope or balance is being driven to the surface a considerable distance north-west of the Aberdeen slope, to serve as a return air-course. From these workings, at a seven-feet fault, samples of crude petroleum have been obtained associated with calcspar veins, resembling its mode of occurrence in thePictou coal measures.*

In this work Mr. Fletcher has again had the kind assistance of Mr. J. R. Cowans and other gentlemen whose names have appeared in previous reports.

For a description of recent mining operations at Springhill and the smaller collieries of Joggins, Chignecto, Minudie, Strathlorne and Jubilee, on the north side of the Cumberland basin, the Canadian Mining Manual and the Nova Scotian, pages 17 to 20, may be consulted. Of these collieries, Springhill furnishes as its share of the Intercolonial railway contract for coal 80,000 tons, Joggins 15,000 tons, Minudie 15,000 tons, Strathcona 5,000 tons.† Coal is now taken from the 1,400 feet level at Chignecto mines.

Magnetic iron ore.

Systematic search was begun last summer by Mr. Lindsay on the deposits of magnetic iron ore found in irregular masses and veins among the traps of Gerrish mountain,‡ but up to the present time no mass of workable size has been found.

Copper of Cape d'Or.

At Cape d'Or, the Colonial Copper Company has, during the last three years, expended some hundreds of thousands of dollars in exploiting the deposit of native copper also found, like the magnatite, in

*Poole's Pictou Coal Field in the Trans. N.S. Inst. Sc., Ser. 2, vol. I, Part 3, page 319.
†Maritime Mining Record, Dec. 9, 1903, pp. 14 and 16.
‡Sum. Rep. for 1891, page 36.

Triassic trap* in irregularly scattered grains, plates and lumps sometimes weighing fifty pounds, in veins and dykes carrying quartz and zeolites. Several shafts have been sunk, one to a depth of 371 feet, with drifts and tunnels at intervals; machinery capable of treating 400 tons a day has been erected, and a railway, one mile and a quarter long, built to convey the ore from the mines to the mill.

Near William Warwick's at West New Annan, one of the irregular deposits of sulphides of iron, copper and other metals, said to carry gold, exploited from time to time in the Cobequid hills† was developed to some extent last summer. New Annan.

During the autumn two visits were made to Stanley in Hants county where a government diamond drill was at work on the right bank of Kennetcook river, nearly opposite the gravel pit at the station on the Midland railway. The cores to a depth of 485 feet consist of red and gray sandstone and shale, red predominating, but no trace of coal was met, although in the neighbourhood are found the indications observed by Sir William Dawson, who writes of them as follows :—‡ Coal of Kennetcook river.

'Indications of coal have also been observed in the coal measures band extending from Lower Stewiacke toward and along the Kennetcook river. These measures are not well exposed, and I believe that nothing definite is known as to their real value. The occurrence of coal in this central district would, however, be of so great importance to the province, and to the success of its main line of railway, that the subject well merits a thorough investigation'.

Some attention was also paid to the borings with a calyx drill at Port Hood,§ which have enabled us to fill up the gaps in the coast section below the main seam, down to the strata so well exposed in the cliffs at and near Cape Linzee, Sheet No. 16. Borehole No. 3 on Smith island, after passing through about 300 feet of the gray sandstone of Susannah point, with bands of conglomerate, cut 300 feet of the red Lower Carboniferous strata which underlie these gray sandstones along the shores of the island. Boring at Port Hood.

Borehole No. 1 began immediately below the outcrop of the main coal-seam near the Tremaine or present working slope; No. 2 was bored on the west bank of the millbrook (Little river), a few yards above the

---

*Acadian Geology, page 107. N. S. Depart. of Mines, 1876, p. 63; 1901, page 71. Can. Mining 1903, p. 72. Geol. Survey Ann. Rep., 1889-90, Part P., page 186. Sum. Rep. for 1901, page 214.

†N. S. Depart. of Mines, 1880, page 13, *et al.*

‡Acad. Geol., pp. 268, 269 and 276. Sum. Rep. for 1889, p. 30; for 1893, p. 41.

§Report for 1882-84, Part H., pp. 47, 56, 57 and 88. Sum. Rep. for 1900, p. 164, for 1902, p. 390.

shore road; and No. 4 on the Little Mabou road, 200 yards north-east of the fork of the shore road. The section of No. 2 seems to commence about 477 feet below the top of No. 1 and to contain all the strata of No. 4, which commences about 77 feet below its top. The thick sandstone cut in all three holes, with an underlying coal seam, is apparently that of the section at Isthmus point given in the Geological Survey Report for 1882-84, page 57 H (Nos. 8 and 10 of the section.)

Port Hood mines.

An output of 95,000 tons of coal has been obtained by the Port Hood Coal Company from their mines during the past year. The slope is now down 1,576 feet, with a sump seventy feet below the lowest level. This level is driven north 2,500 feet and south 900 feet, the seam being 6 feet 3 inches thick on the south side, and 7 feet 3 inches on the north. A subsidy of $20,000 has been voted by government this year to help to restore the bar and make shipping safe at the wharf which is 3,000 feet from the engine at the bankhead.

Mabou.

The slope at Mabou coal mines is 100 feet under the sea with 350 feet of cover at the water line,* and interesting developments have been made in the sinking, although little coal has been shipped. The slope is now being re-timbered, preparatory to testing the continuance of a flattening of the coal to 6 feet at the face.

Inverness.

Since the completion of the railway to Port Hastings and Point Tupper, the production of coal from Inverness (formerly Broad Cove) mines has also largely increased.† Here a government calyx drill (No. 7) was employed to determine the character and thickness of rock-cover over the present working seam at the shore.

The large drill used at Port Hood has been removed to Chimney Corner coal mines.

Explorations at Cheticamp.

Exploratory work is still being prosecuted at Cheticamp on the extensive deposits of mixed sulphides, sometimes rich in gold and silver, which are described in Report A for 1898, page 148. A 'grab sample' taken by Mr. F. H. Mason, of Halifax, 'assayed nearly three ounces of gold, besides silver and copper values.' The presence of metallic ores in this region, pointed out by Mr. John Campbell in 1862, Professor Hind in 1870, the Geological Survey in 1881, aud many others‡ has led to costly explorations at various times.

*Maritime Mining Record, Dec. 9, 1903, page 15. Rep. for 1882-84, Part H, pp. 61 to 71, 88 and Sheets 14 and 15. Brown's Coal Fields of Cape Breton. Gilpin's Mines of Nova Scotia. Reports of N.S. Depart. of Mines.

† Report for 1873-4, pages 182, 183 and 188 to 191; for 1882-4, pages 14, 71 to 74 and 88 H, with map sheet. Sum. Rep. for 1900, p. 164.

‡ Rep. for 1882-4, Part H, pages 22, 39, 95, 97, etc.

On the eastern side of this northern tableland, at Aspey bay, a deposit of galena in limestone, like that of Pleasant bay* rests directly upon granitic rock, the ore following here, as elsewhere, the contact of the Lower Carboniferous with pre-Carboniferous rocks.

Towards the end of July, Mr. Fletcher visited the north shore of St. Anns, in Victoria county, where indications of workable coal were reported to have been discovered in rocks coloured Lower Carboniferous on the geological map of that district. These reports were found to rest entirely on the occurrence of certain black bituminous shales, containing carbonized plants and coaly matter, which have often been mistaken for coal.† Near the mouth of Little river, at the house of Mr. Angus Matheson, broken land indicates the probable existence of limestone, and this has actually been dug in a well and pit near the house. Along the shore, the strata of the reefs are nearly horizontal: the most prominent rock at low-water is a band of gray, jointed, fossiliferous limestone, underlaid by coaly shale and coal of no great thickness, succeeded beneath by a dark calcareous underclay, full of rootlets. Farther south, the cliffs expose conglomerate, grit and light-gray, micaceous, sandy flags and shales, with thin layers of black shale, apparently all Lower Carboniferous. Pits and boreholes put down along the shore show no indications to support the claim that workable coal had been found. Coal reported at St. Anne.

The land between the shore and the felsitic rocks of the mountain is nearly a plain, greatly broken by plaster-pits, as shown on the map. Good outcrops of marl and gypsum occur at many points, backed by the felsites which, towards St. Ann's harbour, are again being exploited for gold and metallic ores.‡

Application has, it is said, been made for the use of one of the government drills to bore the Lower Carboniferous, so called coal seams of Hunters mountain, about eight miles from Baddeck.¶ At Hunters mountain.

Near Boisdale several days were spent, about the middle of August, with Mr. S. Ward Loper who was again collecting, for the United States Geological Survey, fossils described by Dr. G. F. Matthew in his Report on the Cambrian Rocks of Cape Breton.

Acting on instructions received from Dr. Bell, Mr. Fletcher on October 27 brought before a meeting of the Mining Society of Nova Mining Society of Nova Scotia.

* Rep. for 1882-4, Part H, p. 93.
† Rep. for 1882-4, Part H, pages 46, 52, 53 and 90, and map sheet.
‡ Rep. for 1882-4, Part H, page 94.
¶ Rep. for 1876-77, p. 454. Rep. for 1882-84, part H. page 41. N. S. Depart. of Mines, 1877, page 36. Brown's Coal Fields of Cape Breton, page 37.

Scotia some of the results of the work of the Geological Survey in Cumberland county, principally on the coal measures in their relation to the overlying rocks, illustrating his remarks by maps of the district; and when in Halifax at that meeting he assisted Dr. Poole in revising a new map of the Pictou coalfield.

Explorations in the Sydney coal field.

A considerable amount of money was spent last summer by the Cape Breton Coal, Iron and Railway Company in explorations along the outcrop of the Tracey seam, under the advice of Professor Ray and Dr. H. S. Poole, in continuation of those made by the late Mr. E. T. Moseley and Senator MacKeen.

Sum. Rep. for 1901, p. 208; for 1895, p. 107; for 1896, p. 95; for 1897, p. 102. Report for 1874-75, p. 139; for 1875-76, p. 414. Note on the Sydney Coal Field (No. 685) with maps, p. 7.

SPRINGHILL, N.S., Dec. 18, 1903.

GOLD FIELDS OF NOVA SCOTIA.

Mr. E. Rodolphe Faribault.

Office work by Mr. Faribault.

Mr. Faribault was engaged in office work from October 22, 1902, until June 9, 1903, and from July 13 until August 4, 1903. The greater part of this time was spent in plotting plans and sections from surveys made by himself and his assistants during the previous summer, as detailed in the Summary Report for 1902, pages 399 to 427.

Much time was also taken up in correspondence, especially answering letters from persons seeking information and advice on the gold fields of Nova Scotia, which are attracting more and more attention from scientists and capitalists at home and abroad.

Report on deep gold mining to government of Nova Scotia.

At the request of the government of Nova Scotia, Mr. Faribault has prepared a report with plans and sections, entitled 'Deep Gold Mining in Nova Scotia,' which has since been printed for distribution among those interested in gold mining. The legislature of Nova Scotia, at its session of 1903, passed an act authorizing the Governor in Council to appropriate a sum of money sufficient to assist in the sinking of deep shafts, in such places as may be determined, under the direction of the Inspector of Mines. The government is to bear half the expense of the actual sinking from the surface to a vertical depth not exceeding 2,000 feet.

Plans of gold districts published.

The plans and sections of the gold districts of Isaacs harbour, Cochran hill, Wine harbour and Harrigan cove surveyed the year previous, and that of Gold river, surveyed in 1901, were completed

for publication. The plans of Isaacs harbour, Cochran hill and Gold river are now being published, while those of Wine harbour and Harrigan cove only require to be traced for engraving. These mining plans are impatiently awaited by those interested, to guide them in their operations, and they will be published as soon as completed.

Mr. Owen O'Sullivan of this department was engaged some four months during the winter in compiling the topographical surveys of the region lying immediately west of the line of the Intercolonial railway between Halifax and Elmsdale, and extending northward to Rawdon and Newport and westward to the main road leading from the latter place to Sackville and St. Margaret's bay. The compilation of the instrumental surveys made for several years past in the counties of Halifax, Hants and Lunenburg is still in arrears, but it will be pushed vigorously and completed for publication. Publication of maps.

On the field work accomplished in the gold fields of Nova Scotia during the past summer, Mr. Faribault reports as follows :— Field work in the gold fields of Nova Scotia.

In accordance with your instructions, I left Ottawa on June 9, for Halifax, N.S., where I met my assistants Messrs. A. Cameron and J. McG. Cruickshank, as well as Mr. M. H. McLeod, transferred for this season from Mr. Fletcher's party, and from thence proceeded to the interior country lying to the north of St. Margarets bay to examine that region and define the surveys necessary to complete the mapping of the area lying between Mr. Fletcher's work on the north and my own on the south. I returned to Ottawa at the end of June, but left again for Nova Scotia on Aug. 14, where I remained until early in October, my assistants continuing field-work up to October 18.

Owing to important new mining developments made or contemplated in many gold districts by means of vertical shafts on anticlinal systems of saddle veins to establish a new method of deep mining and on account of numerous requests received for geological information of use in these operations, much of my time was spent, by Dr. Bell's instructions, in making examinations of several gold districts beyond my field of systematic work. New methods of deep mining.

The following gold mining districts were examined :—Isaac's Harbour, Country Harbour, Wine Harbour, Goldenville and Miller's Lake in Guysborough county; Ecum Secum, Harrigan Cove, Fifteen-mile Stream, Caribou and Oldham in Halifax county; Mount Uniacke in Hants county; Gold River, Leipsigate, Indian Path, Voglers Cove and Pleasant River in Lunenburg county and North Brookfield, Molega, Whiteburn, Fifteen-mile Brook and Mill Village in Queens county. The eight last named districts were visited for the first time Gold districts examined.

to ascertain their geological structure, as compared with those of the eastern part of the province, in order to arrive at some general conclusion as to a classification of all the gold districts and their suitability for deep mining. Some data were also collected on the bog iron deposits, prospected in Halifax county at Newcomb Corner, along the south side of the Musquodoboit river and as far west as Fall river; on the limestone, gypsum, ochre and supposed coal deposits of Mahone bay Lunenburg county and the Dominion Antimony Company's mine at West Gore, Hants county. At the end of the season's work, several days were spent with my party at New Ross, Lunenburg county, to examine the mode of occurrence of minerals and intrusions met with in this granite region.

Iron, antimony, ochre, etc.

Acknowledgments.

In the performance of my field-work I have received valuable information and assistance from miners and others in Nova Scotia and I wish to offer especially my acknowledgments to the following persons: Hon. A. Drysdale, Commissioner of Works and Mines, Dr. Edwin Gilpin, Inspector of Mines, Dr. M. Murphy, Provincial Engineer, Dr. H. S. Poole, Prof. J. Ed. Woodman, and Messrs. F. B. Wade, K.C., M.P., Harry Piers, Curator Provincial Museum, Alex. McNeil, K.C., F. H. Mason, D'Arcy Weatherbe, Fred. P. Ronnan, and F. J. Tremaine, K.C., of Halifax; James A. Fraser, New Glasgow; G. J. Partington of Isaacs Harbour East; W. F. Fancy, Isaacs Harbour; Ch. M. Donohoe, Goldboro; J. C. McDonald, Country Harbour mines; S. R. Heakes and Matthew McGrath, Wine Harbour; Arthur G. McNaughton and Wm. McIntosh, Goldenville; George W. Stuart, Truro; Monroe Archibald, Walter C. Boak and E. H. Oland of Harrigan Cove; L. W. Getchell, Caribou mines; Ed. Whidden, Oldham; Jas. A. Crease, Geo. E. Johnson, Mount Uniacke mines; C. Noble Crowe, West Gore; Prof. G. S. Kennedy, Dr. H. Y. Hind and Clarence H. Dimock, Windsor; Charles Keddy, Lake Ramsay; C. U. Mader and Dr. C. A. Hamilton, Mahone Bay; V. J. Paton, T. W. Moore, Dr. Henry W. Cain and H. S. Badger of Bridgewater; W. L. Libbey, North Brookfield; R. R. McLeod, Brookfield; Samuel Sutherland and D. McD. Fraser, Molega gold mines; W. H. Banks, Caledonia Corner; Gordon C. Smart, Whiteburn; and James Sheriff, Fifteen-mile Brook near Middlefield in Nova Scotia; also John E. Hardman of Montreal.

Last season's surveys are not all plotted and the results have not yet been fully made out, but the following summary of information and conclusions are given subject to revision.

UPPER ISAACS HARBOUR GOLD DISTRICT.

An examination was made of the underground development works in progress at the Dolliver Mountain and Richardson mines.

Dolliver Mountain mine.

Dolliver Mountain Mine.—The vertical shaft on the anticlinal fold has attained a depth of 337 feet and has already intersected five saddle veins. From data kindly supplied by the resident manager, Mr. G. J. Partington, a transverse section made through the vertical shaft is here reproduced to show that the structure of the saddle veins is the same as it was at their cropping, further west and proves their recurrence in depth. The section need not be described as it is self-explanatory.

Section of saddle veins developed by vertical shaft.

Some 8,000 tons of ore have already been taken out, mostly from development tunnels and cross-cuts on the Partington belt; they were milled separately and the distribution of the gold plotted on large scale plans. These plans are most interesting and valuable. They show at a glance the distribution of the ore values, and prove that some portions of the saddle veins are not profitable, while others give pay-values which are now being traced by stoping to determing the pay-choots which will probably be found to pitch eastward 16°, like the apex of the saddle.* As far as the developments have gone it appears that the ore on the arch-core of the fold is probably of too low grade to be worked with profit, while at a certain distance below the apex the ore is richer. On account of the great size of the veins the preliminary developments were necessarily extensive and costly, but the knowledge gained on the Partington saddle will now be available and valuable in the development of underlying saddle veins, as it is probable that the pay-choots on the various veins occur in the same relative position on the anticline, and extend in depth in a direction nearly parallel with the apex of the fold. Should the Partington saddle prove unprofitable it does not follow that the underlying saddle veins will also be so, and I am pleased to learn from advice just received that the ore recently taken out from the apex of the Forge saddle, at the No. 2 level, 309 feet below the surface, shows good plate values in the mill and gives evidence of good battery values also, judging from the amount of mercury required. In Bendigo (Australia) profitable saddle reefs occur only every 300 or 400 feet in depth, on an average. The sinking of the vertical shaft has been discontinued, while developing the station at No. 2 level, but it will be resumed shortly.

* Summary Report Geol. Surv., Can., 1902, p. 424.

Richardson mine vertical shaft.

Richardson mine.—The Boston-Richardson Mining Co., which has recently acquired the property, has enlarged the vertical shaft, which was sunk by the old company on the anticlinal fold, into a three compartment shaft, 19 x 6 feet, in the clear, with a view to deep mining. The present depth of the shaft is 180 feet. Between the depths of 130 and 160 feet, five new veins were intersected, measuring respectively 8, 5, 7, 5 and 6 inches of quartz, and several other leg veins of greater size will undoubtedly be cut before intersecting the Richardson saddle vein at the estimated depth of about 375 feet.

Upper Isaccs Harbour anticline.

Mr. W. F. Fancy has recently located the anticline between Isaacs Harbour and Country Harbour, by surface prospecting, on area 576, Block 18. Assuming that there is no important fault between this point and Isaac's Harbour, it should cross the main road up the harbour at the south side of area 454, Block 6, or about 240 feet further south than indicated on the published plan of Upper Seal Harbour gold district.

COUNTRY HARBOUR GOLD DISTRICT.

Country Harbour gold district. Structure of anticlinal fold.

Assisted and profiting by Mr. J. C. McDonald's intimate knowledge of the district, I succeeded in making out its general structure in a more satisfactory manner than had hitherto been done. The district is situated on the east side of Country harbour river and forms part of a large block of country which has been swung to the south by a main cross-country fault following the river valley. All veins worked in the district have thus a general northand south direction; they follow the planes of stratification and occur on the western dip of the main anticlinal fold.

The anticline was located with certainty at two points namely, at the north-west side of area 1064, where a ledge of whin crops out prominently on the northwest side of a small brook, and at the south corner of area 1340, about 200 feet directly east of the Morrison shaft. At both places the anticline shows a decided pitch to the south and on area 1340 a quartz vein curves on the apex of the fold with rolls pitching south at an angle of 15°. This would seem to prove that the pay-choots on the leads dip to the south at a low angle. Immediately east of the anticline the rocks are concealed, but further away dip east at a low angle, and on the west side they curve abruptly and assume rapidly a steep westerly dip.

Zone of pay-ore.

From knowledge gained in other districts it might be inferred that workable veins are confined to the western leg of the fold and that the zone of special enrichment should occur close to and parallel with the

anticline. As the anticline has a pitch to the south, the strata and the main leads do not run quite parallel with it at the surface but approach it towards the south until they eventually curve around it and assume an easterly dip. As a result the pay-choots will probably crop at the surface on the different leads along a line approximately parallel with the anticline and systematic prospecting along that line should develop pay-choots on other leads towards the north and south, probably as rich as those already worked so successfully on the Mason and Prince leads. In depth the axis-plane of the anticline dips eastward; consequently, to keep in the pay-zone and develop new pay-choots on underlying adjacent veins, cross-cutting to the east should be done as greater depth is attained

Several dykes and spurs of granite from adjoining granitic masses intersect the auriferous strata and veins of the district, generally at a slight angle, and in the underground workings they occasionally interrupt the pay-choots. The veins intersected are not much displaced and appear to continue their original course beyond the granite intrusion, except further south in the vicinity of the main river-fault, where they are much disturbed. The rocks are much altered in places, but the richness of the vein and the pay-choots within them do not appear to be otherwise affected, which goes to prove that the granite intrusions are more recent than the impregnation of the auriferous veins. Granite intrusions.

GOLDENVILLE GOLD DISTRICT*.

Bluenose mine.—Since last year's visit, the main shaft on the old Springfield belt has been sunk to a depth of 485 feet and at 460 feet, or 100 below the second cross-cut, a third cross-cut was driven north 90 feet, intersecting the McNaughton belt 74 feet from the shaft. On that level, drifting and stoping are being done west 200 and east 30 feet. The west face of the drift shows better ore than the east and the structure of the belt indicates that the pay-choot pitches westward and that developments should be pushed in that direction. The company will wisely continue the third cross-cut until it reaches the anticline, so as to intersect the Faribault belt and other large saddle veins cut in the second cross-cut, as well as others underlying, and test the north-dipping veins on the Cantley crumple. The McNaughton belt has now been worked for 900 feet in length and 265 feet in depth. The ore on the apex of the saddles does not appear to be as rich as lower down on the legs, as was also found to be the case on the Partington saddle vein at Dolliver mountain. Detailed plans and sections should Goldenville district. Bluenose mine. Development of new saddle-veins.

*Summary Report Geol. Surv. Can. 1902, p. 421.

be kept at this mine to record the values extracted as they would greatly assist in determining the pay-choots.

Nova Scotia and Mexican mine. Veins developed by vertical shaft and cross-cuts.

Nova Scotia and Mexican mine.—Mr. Stuart's new vertical shaft, on area 743 at Goldenville, has reached a depth of 160 feet, and at this depth cross-cuts have been driven north 180 feet and south 198 feet, intersecting some thirty-five quartz veins of different sizes, several of which are reported to show gold. In the south cross-cut, 74 feet from the shaft, a slate belt 10 feet wide includes seven well mineralized quartz veins, three of which show free gold, and a mill test of the whole belt is said to have given a satisfactory result. This new development shows that the pay-choots cropping out at the surface and for the most part worked out, are underlaid by others of equal richness on adjacent veins, and that the south zone of special enrichment may be proved to have great depth, as well as surface extent where it has been proved for an aggregate length of 4,400 feet across the south dipping leads, from the Bluenose to the Palmerston workings. But it must be remembered that the pay-zone dips north and receedes from the vertical shaft, as greater depth is attained, necessiting longer cross-cuts northward.

MILLERS LAKE GOLD DISTRICT.

Millers lake district preliminary survey.

A preliminary survey was made of this newly discovered district but a full description of its structure must be deferred. The district is situated at the western extremity of Guysborough county and is reached from the Ecum Secum bridge on the Atlantic coast by a rough road four miles and a half in length. Mining areas have already been taken up for a length of some two miles east and west between Millers lake on the East brook of Ecum Secum river, and the foot of the Big Stillwater on Liscomb river.

Structure of anticline.

All the veins discovered so far follow the planes of stratification, on both dips of the Gegogan Harbour anticline, close to the axis. This anticline crosses Millers lake at its outlet, and was traced thence some two miles to a short distance below the foot of Big Stillwater. The fold pitches eastward. On the north side the strata dip north at an angle increasing rapidly to 45° and 58° and on the south side, still more abruptly south to 50° and 75°. The leads vary from a few inches up to twelve inches, while a few rolls of quartz, generally auriferous, reach eighteen inches in thickness and pitch east like the anticline. A great number of leads have already been uncovered and some which are auriferous were prospected along their course for short distances by open cuts or shallow pits, but no important mining developments have

yet been undertaken. Rich float has been found at different points along the anticline and further prospecting will undoubtedly uncover veins of workable value. As far as present developments have gone, the zone of special enrichment appears to run parallel and close to the anticline, but it is hoped that fuller information on this point can be given when the surveys are plotted.

Rich float.

HARRIGAN COVE GOLD DISTRICT.

Harrigan cove district. Boak property, shaft on anticline.

On the Boak property a vertical shaft, started on the apex of the south anticline at the south end of area 384, had, on November 24, attained a depth of 68 feet and cut nine new saddle veins, ranging from one to six feet, all in whin, no slate having yet been cut, The quartz on the apex is coarse and contains sulphides but does not appear to hold free gold. The company operating intend to sink to greater depth before cross-cutting to intersect the south legs of the saddles cut in the shaft, where they will be found smaller but undoubtedly much richer than on the apex.

OLDHAM GOLD DISTRICT.

Oldham district. Sterling property saddle-veins developed.

Last summer the water was pumped out of the old workings on the Sterling barrel lead, situated on the east turn of the anticlinal fold, and the opportunity was taken to visit the developments made some twenty-five years ago. Two slopes or inclines starting from the same deck-head have been sunk on the eastern dip of the belt. The most southerly of these is 250 feet deep and at the bottom it is 120 feet from the northerly slope which is 430 feet deep. At 112 feet from the surface in the latter a tunnel is driven east along the anticlinal fault to a vertical shaft situated 264 feet from the mouth of the slope. This shaft is about 120 feet deep and is reported to intersect several saddle veins, which could not, however, be observed at the time of my visit, as the shaft had not yet been cleaned up. This may be considered one of the earliest attempts made in Nova Scotia to develop new underlying saddle-veins on the anticline. A mill test of 35 tons, recently taken, gave 85 ounces of gold, which is very encouraging.

Napier property. New saddle-veins developed by vertical shaft.

It is of interest to note, from information only recently obtained that the vertical shaft sunk, some twelve years ago, on the anticline, at area 103 of the Napier property, attained the depth of 214 feet and intersected seven new underlying saddle-veins which do not crop at the surface, two of which are reported by the operator to have shown quartz of a sufficiently high grade to justify further development. Judging from the surface developments already accomplished in the

district it would appear that the dome of the anticlinal fold, to the west of the Black brook, in the vicinity of the schoolhouse, is the most advantageous location for a deep test shaft.

MOUNT UNIACKe GOLD DISTRICT.

Uniacke ditrict, West lake property. Recurrence of rich quartz crumples proved.

An examination and a survey were made of the old underground works and of recent operations on the West Lake property. Sections were prepared and two are here reproduced, No. 849*. The general section shows four crumples of rich quartz operated on a subordinate fold, 650 feet south of the main anticline, which have evidently originated during the folding of the strata and are probably underlaid by others as rich and as large. The structure of the fold would lead to the conclusion that the several unproductive veins and slate belts uncovered at the surface to the north of the Borden lead may also form large deposits of quartz and become rich in gold on underlying crumples. On my recommendation the company is now sinking the main shaft on the Borden lead below the crumple to intersect the underlying crumples.

At the Hurrane Point and North Star mines the same conditions exist and the rich quartz crumples already worked at both mines are undoubtedly underlaid by a succession of others which are likewise very promising for deep and permanent mining.

Promise for deep mining.

This succession of crumples offers a great field for future operations on a large scale and may be developed most advantageously by an inclined shaft along the axis of the fold or by a vertical shaft sunk at a certain distance north of the outcrop of the fold and by a succession of cross cuts at different depths to intersect the crumples.

Gold production.

The production of gold from the West lake and Nugetty crumples is—

1142 ozs. 14 dwt. 2 grs. extracted from 1472 tons crushed.

That from the Borden crumple is—

2991 ozs. 10 dwts. from 2121 tons crushed.

Origin of gold.

The two sections illustrate beautifully the intimate relation between the deposition of the ore bodies and the structure of the strata, and give more evidence on the origin of gold. The rich ore-bodies are confined to the slate belts at the crumples, pitching eastward under 18°. The auriferous quartz crumples are connected along the axis plane of the fold by quartz stringers, generally barren of gold and well

*The scale of the general section should read 50 ft. instead of 25 ft. to one inch.

called "feeders" by local miners. From a close study of these "feeders" in th's and other gold districts we are lead to the conclusion that they are the channels through which came the *upward moving waters* which concentrated the gold and associated minerals, finally deposited at the most favourable places in certain slate belts along the apex of the folds, constituting a well defined zone of special enrichment.

CYANIDE PROCESS FOR EXTRACTION OF GOLD.

Mr. H. S. Badger has lately introduced in Nova Scotia a cyanide process for the extraction of gold from the tailings of the quartz mills which were formerly lost. Old tailings accumulated for years and new tailings straight from the mill have apparently been treated successfuly and profitably by this process at the Caribou, Richardson, Leipsigate and the North Brookfield mines. Practical cyanide process for gold extraction in N. S.

The introduction into Nova Scotia of a practical process of extracting gold from the sulphides contained in the tailings means much for the successful future of gold mining in the province, especially in the case of large low-grade ore deposits, such as the Richardson, Dolliver, Bluenose &c., where there is only a small margin for profit.

Cyanide Plant at the Mic-Mac Mine, Leipsigate—At this mine a cyanide plant has been in operation since last February, with apparent success. It includes four treatment vats 16 x 5 feet for sand tailings and two settling tanks for slimes. The slimes are not treated at present, but the intention is to elaborate the plant so that their values may be extracted later. The strong solution (·25 per cent) is allowed to cover the sands about three inches, and after leaching, is strengthened gradually, until it comes out at the stopcocks the same strength as going in. The sands are then washed and the total period of leaching, from the time the strong solution flows into the tank until the clean water comes out in the launders, is about 30 hours. These tanks hold nearly 50 tons and one is filled and one emptied each day. At present "stock" is being taken from the old tailings bed as well as from the plate discharge. Cyanide plant of Mic-Mac mine.

The following notes and figures will, no doubt, prove interesting, as the apparent success of the work at this mine may be repeated at many other localities.*

'The facts were kindly furnished by Mr. H. S. Badger, who is in charge of the milling plant at the Mic-Mac mine. H. S. Badger's notes on cyanide process at Mic-Mac mine.

'The gangue of the ore is a calcareous quartz, containing slate and 'gouge.'

* Report Dept. of Mines, Nova Scotia, 1903, page 60.

'By assay, the ore gives per ton $10.58 worth of gold and the concentrates are sulphides of iron, copper, lead and zinc.

'By amalgamation it is found that the best recovery that can be got on the average was about $7.08 per ton.

Cyanide plant installed.

'It was therefore decided, after experiment, to put in a cyanide plant. This was completed in February, 1903, at a cost of $5,000. The plant has a capacity of about 50 tons per 24 hours, and operations were commenced on February 22.

'The idea is to eventually treat the tailings from the mill plates alone; but in the meantime the old beds are also being treated. Difficulties are met here as the 'sharps' and 'slimes' often lie in separate layers, and mixed in places with organic matter, &c., which retards lixiviation.

'Altogether 5,104 tons of stock valued at $3.78 per ton, or a total value of $18,295 were treated, and an extraction made of 74·9 per cent., equalling as shown by the mint returns $2.83 per ton.

'The total cost of producing this is $1.05 per ton, divided as follows:—

Labour for charging tanks	$ 0 26
" discharging tanks	0 09
Technical staff, including management	0 34
Cost of chemicals, per ton	0 33
Time for precipitation	0 03
Total cost per ton	$ 1 05

'It must be borne in mind, as stated above, that about half the stock treated was from the old beds, thus considerably raising the cost of treatment as well as lowering the percentage of extraction. Again, the mill tailings contain about 50 per cent of slime, worth about $2.25 per ton, or say $1.15 per ton of ore. At present the recovery from these is very limited, but as soon as possible, arrangements will be made to separate these properly and treat them to advantage.

Average value of bullion produced.

'The average value of the bullion produced by the cyanide process at this mine is $16.26 per ounce, composed of:—

Gold	792·90	parts.
Silver	126.00	"
Base metals:		
Zinc, Lead, Copper	81.10	"
	1000.00	

Bog Iron Ore.—Several deposits of bog iron ore have been observed to occur in low sampy places generally overlying belts of the Upper slate division of the gold-bearing rocks, from which they originated by the decomposition of the iron sulphides contained therein. Eleven specimens of bog iron ore received from Mr. F. J. Tremaine of Halifax, have been analysed by Dr. G. Christian Hoffmann, as follows :—Nos. 1, 2, 3 and 4, Guysborough Road, Knodell's Farm ; No. 5, Ship Harbour Road, east of Musquodoboit ; No. 6, three miles east of Black Brook, Musquodoboit ; No. 7, Hill Top, Musquodoboit ; No. 8, 'Bog,' Musquodoboit ; No. 9, Black Brook, Musquodoboit ; No. 10, Reddan's Farm, Newcomb Corner, Musquodoboit ; No. 11, Fall River, north of Waverly, Halifax Co. Equal weights of material were broken off each specimen, finely powdered, and most thoroughly mixed, thereby ensuring a fair average sample of the whole eleven specimens. An analysis of this gave :—

Bog iron ore prospected in Halifax county.

Analysis by Dr. Hoffmann.

Ferric oxide	64·04
Ferrous oxide	9·27
Manganous oxide	2·14
Alumina	0·68
Lime	1·55
Magnesia	0·68
Phosphoric anhydride	0·04
Sulphuric anhydride	0·30
Silica	5·65
Water, hygroscopic	3·37
Water, combined	10·53
Organic matter	3·22
	101·47
Metallic iron	52·04
Phosphorus	0·17
Sulphur	0·12

The foregoing analysis shows it to be an excellent ore of its kind. Certain bog iron ores from the province of Quebec have been found to contain the following percentages of metallic iron :—Ore from Petite Côte, Vaudreuil, 52·15 ; ore from Côte St. Charles, Vaudreuil, 53·86 ; ore from St. Maurice Forges, 54·32, 52·01, 45·36 and 54·36 respectively ; ore from Upper Rocky Point, Eardley, 54·46.

Area surveyed by assistants in Lunenburg and Hants.

Granite.

In Hants and Lunenburg counties my assistants, Messrs. A. Cameron, J. McG. Cruickshank and M. H. McLeod, were engaged the whole summer surveying the head waters of the Indian, Ingram, Middle and Gold Rivers, flowing south into the Atlantic, and those of

the St. Croix and Avon rivers, running northward into the Bay of Fundy. The area surveyed covers 360 square miles and completes sheets 72, 86 and 87 which had been left unsurveyed between Mr. Fletcher's work to the north and my own to the south. This completes Halifax and Hants counties, while Lunenburg is also all surveyed with the exception of a small area at the west corner of the county. The country is underlaid with granite and is for the most part very rough with huge blocks and debris of this rock strewn all over the surface, making travelling very difficult. In Nova Scotia granite is not generally considered a favourable rock for the occurrence of minerals of economic importance, nevertheless several minerals have been observed in the vicinity of New Ross.

New Ross manganese mine.

Float of manganese ore has been discovered at several places to the north-east of New Ross which point to important deposits. One mile west of Wallaback lake a vein of this mineral was discovered a few years ago running in a northerly direction. It has been mined to the depth of 112 feet and some 50 feet in length. At the outcrop the vein is wholly composed of limonite, which passes at the depth of six feet into an association of specular iron ore and manganite and, a few feet deeper, into a mixture of pyrolusite and manganite. A similar vein has been slightly prospected about two miles further to the north-east.

Other minerals.

Molybdenite, zinc-blende, smoky and black quartz, fluor-spar, calcite, mica, tourmaline, garnet, scapolite, pyrite and chalcopyrite have also been observed in veins in the granite. Magnetite and argentiferous galena were found in the drift, and deposits of clay suitable for the manufacture of building brick occur at several places.

Patch of gold-bearing rocks in granite.

A patch of the Cambrian gold-bearing slate and whin from one to two miles in width and 15 miles in length occurs in the granite to the north of the road leading from Vaughan to New Ross and crosses about the middle of Wallaback lake where several quartz veins were observed, one of which is said to have shown gold. A dyke of fragmentary white quartzose rock, cemented with red jasper, susceptible of taking a good polish, occurs half a mile east of New Ross where it runs north-easterly and has been quarried to a small extent.

Timber and soil.

This granite region is generally well timbered with spruce, hemlock and some pine on the head waters of the Indian, Ingram, St. Croix and Avon rivers, where lumbering is prosecuted. Alluvial soil suitable for farming is not found over any large areas, except on hills of boulder clay and along narrow intervales, but a great number of large hay-marshes are found on several streams.

CHEMISTRY AND MINERALOGY.

Dr. G. C. Hoffmann.

Reporting on the work done in these branches of the survey's operations, Dr. Hoffmann says:— Work of chemical laboratory.

'The work carried out in the chemical laboratory during the past year has, conformably with the practice of preceeding years, been almost exclusively confined to the examination and analysis of such minerals, &c., &c., as were likely to prove of more or less economic value and importance. Briefly summarized it embraced:

'Analyses of several varieties of fossil fuel from various parts of the Dominion, that is to say—Of lignite, from near Halbrite, as likewise from La Roche Percée, Souris river, in the district of Assiniboia; from Knee Hill creek, a tributary of Red Deer river, in the district of Alberta, in the North-west Territory; and from near Enderby, Yale district, in the province of British Columbia. Of coal, from the Springhill district, Cumberland county, and from near McLellan's brook, Pictou county, in the province of Nova Scotia; from the vicinity of Morley, and from the north fork of the Old Man river, section 35, township 10, range 3, west of the 5th initial meridian, in the district of Alberta, North-west Territory; and of an anthracitic coal from the north-west quarter of section 29, township 24, range 10, west of the 5th initial meridian, also in the district of Alberta, North-west Territory. Analyses of fossil fuels.

'2. Analyses of the following iron-ores, namely—Of magnetite, from near Pincher creek, eastern slope of the Rocky Mountains, district of Alberta, North-west Territory; and from near Enderby, Yale district, in the province of British Columbia. Of hematite, from the Rocky Mountains, south of Blairmore, district of Alberta, in the North-west Territory; and of clay iron-stone from Collins Gulch, Tulameen river, Yale district, in the province of British Columbia. Of iron-ores.

'3. Analyses, partial, of samples of copper-ore from—Westport, Digby county, in the province of Nova Scotia; York county, and from La Tête, Charlotte county, in the province of New Brunswick; from the township of Orford, Sherbrooke county, in the province of Quebec; and from mining location No. 2961, R. 455, north-east of Schreiber, district of Thunder Bay, in the province of Ontario. Of copper-ore.

'4. Analyses, in regard to nickel content, of many samples of pyrrhotite, among which was one from the west-half of the tenth lot

of the fourth concession of the township of Olden, Frontenac county, in the province of Ontario, which was found to contain 1·92 per cent of nickel.

Assays for gold and silver.

'5. Assays, for gold and silver, of samples of material from Mira hill, near Jas. MacMillan's lake, south side of East bay, Cape Breton county, in the province of Nova Scotia; and from Warren's Landing, Mossy Point, northern extremity of Lake Winnipeg, in the district of Saskatchewan, North-west Territory; as likewise from many other localities.

'6. Analyses of building stones, that is to say, of a limestone from the immediate vicinity of Phillipsburg, on the east side of Missisquoi lake, township of St. Armand, Missisquoi county, province of Quebec; and of a limestone from Carswell's quarry, Bryson, lot thirteen of the first range of the township of Litchfield, Pontiac county, also in the province of Quebec.

'7. Analyses, partial, of several graphitic schists from, among other places, the farms of Donald McInnis and McSween, Big brook, near West Bay road station, Inverness county; and from near Baddeck, Victoria county, in the province of Nova Scotia.

Analyses of natural waters.

'8. Analyses of natural waters (with the object of ascertaining their suitability for economic or technical purposes, or possible value from a medicinal point of view) from, among other localities:—A spring at Brook village, about seven miles east-south-east of the town of Mabou, Inverness county; and from a well near the post office at Granville Centre, Annapolis county, in the province of Nova Scotia; the How Spring, on the fifteenth lot of the third concession of the township of Fitzroy, Carleton county, in the province of Ontario; as likewise from a boaring in Courtright, on the eighth lot of Front street, or Front concession as it is sometimes called, in the township of Moore, Lambton county, also in the province of Ontario; and from a hot spring near the city of Vancouver, district of New Westminster, in the province of British Columbia.

Micellaneous examinations

'9. Miscellaneous examinations, embracing the examination, accompanied, in many instances, by a partial analysis, of such material as—Bog manganese (from Prince Edward Island), bog iron ore (from the province of Quebec), coals (from about four miles south of the town of Windsor, Hants county, and from Debert river, Colchester county, in the province of Nova Scotia; and from two miles north-west of Flowers Cove, Grand lake, Queens county, in the province of New Brunswick), limestone (from near Windsor, Hants county, Nova Scotia),

shales (from Peterborough, county of Peterborough, and from the tenth lot of the fourth concession of the township of Cartier, district of Algoma, in the province of Ontario), etc., etc. Also the examination and testing of numerous samples of clay in regard to their suitability for the manufacture of bricks—ordinary building brick, or fire brick, for pottery or other ware, from, among other, the following localities :—Near Baddeck, Victoria county; Irish Cove, Richmond county, and some localities in Hants county, in the province of Nova Scotia; from Dutch Valley road, Sussex, Kings county, in the province of New Brunswick; from near 'The Brook' village, in the township of Clarence, Russell county, province of Ontario; and from the north bank of the Red Deer, south-east quarter of section 20, township 38, range 27, west of the 4th initial meridian, in the district of Alberta, North-west Territory.

'In addition to the foregoing work, five hundred and thirty-six mineral specimens have been examined and reported upon more or less exhaustively. Although this is numerically less than in the preceding year, the actual amount of work involved was very much greater. Very many of the specimens in question were brought by visitors; the greater number, however, were received by mail or express from residents in more or less distant parts of the Dominion.

'The number of letters personally written—chiefly of the nature of reports, and embodying the results of examinations, analyses or assays, as the case might be, of mineral specimens—amounted to three hundred and six; and of those received, to one hundred and fifty-eight. Correspondence.

'I have been most ably assisted by Mr. F. G. Wait in the general work of the laboratory. To this he has applied himself with considerable assiduity, and, as a result, accomplished much in the way of analyses, partial and complete, of minerals and natural waters, in addition to having carried out a great variety of miscellaneous examinations. Mr. R. A. A. Johnston also rendered valuable aid in the carrying out of analyses during the early part of the year.

'In the work connected with the mineralogical section of the museum I have, for the first eight months and a half of the year, that is to say, up to the 11th day of September, been assisted by Mr. R. L. Broadbent, during which time he was engaged in the labelling and cataloguing of newly received specimens and in the maintaining of the collection generally in an orderly condition.

Additions to museum.

'The additions to the mineralogical and lithological section of the museum during the past year embraced :—

A.

A sectional model of the gold district of Goldenville, Nova Scotia; made by E. R. Fairbault, B. A., &c., of the Geological Survey.

Chalcopyrite, from the twenty-sixth lot of the first range of the township of Hatley, Stanstead county, Quebec.

Clay iron-stone, from the so-called twenty-feet seam of coal on Collins Gulch, Tulameen river, Yale district, B.C.

Coal, from the Debert river, Colchester county, N.S.

Coal, from the Bailey and C. W. Wetmore lot, two miles northwesterly of Flowers Cove, Grand lake, Queens county, N.B.

Coal, from near Morley, district of Alberta, N.W.T.

Coal, from the north half of section 9, township 31, range 22, west of the 4th initial meridian, district of Alberta, N.W.T.

Magnetite, from the eastern slope of the Rocky Mountains, near Pincher creek, district of Alberta, N.W.T.

Pyrrhotite, from the west-half of the tenth loth of the fourth concession of the township of Olden, Frontenac county, Ont.

B.

(Collected by members of the staff engaged in field-work in connection with the Survey).

Ami, Dr. H. M. :—

Sand, from the sand hills near Wellington, Prince Edward county, Ont.

Broadbent, R. L. :—

a. Magnesite, a series of specimens of, from various lots and ranges of the township of Grenville, Argenteuil county, Que.

b. Edenite, from the fifteenth lot of the ninth range of the township of Grenville, Argenteuil county, Que.

c. Antimony, native, from the Dufferin mine, on the eighteenth lot of the first concession of the township of Madoc, Hastings, county, Ont.

d. Limestone, from the thirteenth lot of the first range of the township of Litchfield, Pontiac county, Que.

e. Lime, prepared from the same.

Dowling, D. B., B.Ap.Sc. :—

Semi-anthracite, from a seam on the South Branch of Sheep creek, section 11, township 19, range 7, west of the 5th initial meridian, district of Alberta, N.W.T.

Fletcher, Hugh, B. A. :—

Core of sandstone conglomerate from a boring at Bear Brook, one mile and a half below the bridge over the East river at New Glasgow, Pictou county, N.S. Additions to museum.

McConnell, R. G., B.A. :—

Clay, under, from a seam of lignite on Rock creek, Klondike river, Yukon district, N.W.T.

McKinnon, Allan T. :—

a. Gypsum, several blocks of, from the Wentworth quarry, Hants county, N.S.

b. Manganite, several specimens of, from Bridgeville, East river, Pictou county, N.S.

c. Limestone, several specimens of, from same locality as the last mentioned.

d. Gypsum, several groups of crystals of, also from Bridgeville, East river, Pictou county, N.S.

C.

(Received as presentations).

Blue, John, Eustis, Que. :—

Vivianite, from the twenty-fifth lot of the second range of the township of Hatley, Stanstead county, Que.

Haycock, E. B., Ottawa, Ont. :—

Corundum, from the fourteenth lot of the ninth concession of the township of Methuen, Peterborough county, Ont.

Soues, F., Clinton, B.C. :—

Lignitified wood, from the Horsefly Gold Mining Company's property, Horsefly river, Cariboo district, B.C.

In addition to which, Mr. Willimott has received, for the purpose of making up collections, from :—

Mr. D. Farry, of Perth, Ont.—
Shell marl........................ 25 pounds.

Mr. A. McNeil, Halifax, N.S.—
Stibnite........................100 "

Mr. Allan T. McKinnon, (Survey)—
Specular iron ore..................700 "
Manganite.......................700 "

'In the early party of August, Mr. C. W. Willimott was engaged in preparing a collection of minerals for the Dominion Exhibition, then about to be held in Toronto. This he very successfully accomplished by about the middle of the month. As a result of his efforts he Work by Mr. Willimott.

succeeded in bringing together a fine series of specimens illustrative of the mineral resources of the country. This, which weighed in the aggregate some thirty-eight thousand pounds, was forwarded by him to Toronto, and he himself followed shortly after to superintend the installation, which was accomplished in a very satisfactory manner. He remained in charge of the collection until the close of the Exhibition—September the 12th, when, having attended to the packing and reforwarding of the same to Ottawa, he returned to his customary duties at the Survey.

School collections of minerals.

'Previous to entering upon the foregoing work he was, and since his return from Toronto has been, engaged in making up collections of minerals and rocks for various Canadian educational institutions. The following is a list of those to which such collections have been sent:—

	Number of Specimens.
Public school, Newtown, Kings Co., N.B.	75
McKeough school, Chatham, Ont.	100
Public school, Rossland, B.C.	100
Literary Institute and School of Arts, St. Hyacinthe, Que.	100
High School, Barnston, Que	100
Dundurn Castle Museum, Hamilton, Ont.	100
High School, Tilsonburg, Ont	100
Creighton St. School, Ottawa, Ont.	100
High School, Uxbridge, Ont.	100
Richmond County Academy, St. Peters, Cape Breton Co., N.S	100
High School, North Bay, Ont.	100
Ursuline Convent, The Pines, Chatham, Ont.	75
High School, Vienna, Ont.	100
Stanford High School, Niagara Falls, Ont.	100
High School, Nelson, B. C.	100
Mutchmore Street School, Ottawa, Ont.	100
High School, Quebec City, Que.	100
Model School, Gananoque, Ont.	75
High School, Sydney Mines, Cape Breton County, N.S.	100
St. Louis Academy, Quebec City, Que	100
High School, Rat Portage, Ont.	100
Collegiate Institute, Sarnia, Ont.	100
Archibald Street School, Ottawa, Ont.	100
Public School, Searletown, P.E.I	75
Collegiate Institute, Cobourg, Ont.	100
St. Ninian's Street School, Antigonish, N.S.	75
College de Valleyfield, Salaberry de Valleyfield, Que	100
St. J. B. DeSalle Academy, Ottawa, Ont.	100
The Ladies College of the Congregation, Victoriaville. Que.	75
Couvent de la Congregation, Arthabaskaville, Que.	75
District No. 2, Parish of St. James, Charlotte County, N.B.	75
Public School, Fergus, Ont.	100
St. Malachie School, St. John, N.B.	100
Fern Avenue School, Toronto, Ont.	100
North Sydney Academy, N. Sydney, C.B., N.S.	100
Public School, Smiths Falls, Ont.	100
Westside School, New Westminster, B.C.	100
Gault Institute, Valleyfield, Que.	100
High School, Montague, P.E.I.	100
Lawrencetown School, Lawrencetown, N.S.	100
Dufferin School, St. John, N.B.	100
The Institute, West Bromwich.	75
Acadiaville School, West Arichat, C.B., N.S.	75
Total number of specimens	4050

WORK OF THE MINES SECTION.

Mr. E. D. Ingall.

On the work of the Mines Section, Mr. Ingall reports as follows :— 'The work of the Mines Section has been continued along the lines followed in past years and the staff has been occupied with the usual collection of data, statistical and technical, relating to the mineral industries and resources of the country and with the work of preparing and putting through press the annual report on these subjects. As usual, a statement giving a close approximation to the mineral production for the previous year was prepared in advance of the detailed general report and issued on the 27th of February. The full report for 1902 was completed and published early in December and contained besides the usual statistical data and explanatory material, special articles on coal, infusorial earth, salt, zinc, etc., similar to those embodied in former reports. Scope of work.

Taking Canada as a whole, the mining industry has been fairly active during the year just closed. Compared with 1902, in some departments there has been an increase in quantities produced, but a decrease in the prices obtained, while in others the opposite conditions have prevailed. After balancing these results against one another and taking into consideration improved, stationary and retrograde conditions in other branches, the nett showing appears to be a slight falling off in the total value. As a class, the totals of the metallic products decreased both in quantity and value, although copper and nickel were notable exceptions in both respects. The total of the non-metallic mineral products showed an increase, but not quite sufficient to offset the decline in the metallic class, so that in the grand total there appears to have been a decrease of about one per cent in the value of the output, which amounted to about sixty three and a quarter million dollars. Mineral production.

The relative values of those individual products, each of which amounted to upwards of a million dollars, were in the following order : (1) gold, (2) coal and coke, (3) copper, (4) building material, (5) nickel, (6) silver, (7) cement. Gold and coal constituted far the largest items, amounting to about 30 and 26 per cent respectively of the total. The diminution in the production of placer gold in the Yukon territory amounted to about 2½ millions of dollars on account of the progressive exhaustion of the richest deposits, but without a corresponding reduction in the industry itself. Relative values.

In connection with the discussions which have taken place at the sessions of the Canadian Mining Institute as to the correct way of Methods adopted.

illustrating the value of Canada's mineral products, it may be as well to mention the standpoint adopted by the Mines Section in its treatment of the subject. It was agreed that it is chiefly essential to correctly ascertain the quantities produced, eliminating all possible errors, and checking where possible by railway shipments, etc. As, however, quantities of such various substances cannot be added together it is manifestly necessary for the purpose of making up the grand total to adopt some basis of valuation which shall be comparable from year to year, so as to rightly illustrate growth. For the metallic ores, whose only uses are as sources of the metals and which are of such varying constitution, the final value of the amounts of the metals contained in the ores is manifestly the only common denominator or standard to which they can be brought. This is the method adopted by the United States Government and by that standard publication The Mineral Industry, issued annually by the Engineering and Mining Journal of New York.

Other methods.

Whilst other reliable authorities may properly adopt other methods equally correct and legitimate, with a view to illustrate the mineral industries from other standpoints, it is believed that the above method best meets the needs of this report. It must be borne in mind also, that this applies only to the general tabulation of the country's total mineral production of all sorts, and that in the Section's full annual report, the details relating to the different industries are given in the body of the publication.

For the non-metallic minerals it is manifest that only spot values can be adopted. They are practically all used as such and their value is a very variable quantity, often, as far as the consumer is concerned, made up mostly of cost of carriage to the point of consumption. Thus the same material would have widely varying values at different points. The only other basis would be to value the material at its point of departure from the producer. This is found still to be only a rough approximation to uniformity, and each separate substance has to be considered by itself. Where there is some point of shipment or distribution common to a district, a more definite and uniform method can be arrived at, as with the phosphate of Quebec which was all handled at Montreal and the price was always quoted f.o.b. at that port.

It must also be borne in mind that no presentment of data, statistical or otherwise, will meet the varying needs of the people likely to be interested in the subject. The consumer is interested chiefly in the price he has to pay for the article; the producer in the value he can realize on his products. The main thing is to have the fundamental

data correct and to adopt a standard so definite and clear that any one can make the allowances necessary for the illustration of the industry from his particular standpoint.

Bruce Mines District.

Mr. E. D. Ingall.

In regard to the work under his charge in the Bruce Mines District, Ontario, Mr. Ingall reports as follows :—

Nature of work.

It had been arranged to proceed with the field-work begun in the summer of 1902 in the Bruce Mines region, and with that intention Mr. Denis left Ottawa on the 4th of July. Owing to pressure of work in the office, however, only three weeks could be spent in that field, during a part of which the weather was very unfavourable. In that time a beginning was made in the delimiting of the several greenstone belts which traverse the district. Two of these were traced out. One, starting just west of the Stobie or Cameron copper mine at Portlock, was mapped from a micrometer traverse through a distance of some three and a half miles. It runs just south of Desbarats lake, has a direction of N. 50° to 60° W., which coincides with the general strike of the rocks. This development of greenstone has the appearance of an intrusive sheet of diabase between beds of quartzite.

The second greenstone area examined, runs along the south side of the Canadian Pacific Railway from the Portlock road eastward. The direction of the ridge, which is nearly east and west was followed for one mile. This intrusion has the character of a boss more than of a sheet. The hand specimens of the rocks of both of the belts examined, seem to show the same constituents and to a great extent the same rock-structure.

Little mining being carried on.

There was very little mining activity in the district during the summer season. The Bruce mines had not resumed work, and the Rock Lake mine had greatly reduced its operations. The line of the Bruce Mines and Algoma Railway has been completed from Bruce Mines village to the Rock Lake concentrator. The Richardson and the Cameron mines were both idle.

During the latter part of the year, however, there have been reports of resumption of activity. Some iron ore locations north of Gordon lake have been tested by diamond drill holes, and the Bruce mines are said to have been purchased by the International Nickel Company, which will perhaps shortly reopen and work them. On his return

trip to Ottawa, Mr. Denis spent a few days in the salt region of western Ontario for the purpose of bringing the data of the Mines Section up to date in regard to the production of salt. His observations are published in the Mines Section report for 1902, part S., Vol. XV.

Mapping and Engraving.

Mr. C. O. Senécal, Geographer and Chief Draughtsman.

Report of Geographer and Chief Draughtsman

I have the honour to submit the following statement of the work accomplished under my supervision during the past calendar year:—

Assignment of work.

Mr. L. N. Richard has drawn and lettered for engraving, and prepared the colour copies of the following maps, viz.:—the Perth sheet (No. 119, Ont.), the Sudbury map, the West Kootenay sheet and the map of Hudson Bay and James Bay (duplicate set of three sheets). He also attended to sundry work passing through the office. Mr. Richard is at present engaged in the preparation of the colour copies of the Haliburton sheet (No. 118, Ont.) and of the Pembroke sheet (No. 122, Ont.), for engraving.

Mr. O. E. Prud'homme traced and lettered the Apple River sheet (No. 100 and 101) and partly sheets Nos. 64, 75, 76, 82 and 83 of the Nova Scotia series of map-sheets; also the plans of Isaacs Harbour, Gold River, and Cochran Hill gold districts of Nova Scotia. He has drawn for photo-lithographing a sheet of sections of the Souris coal-field, the map of ancient shore-lines of Ontario, and a small map for the Summary Report. He also prepared the colour copy of the Bancroft map, attended to miscellaneous work and to the distribution of maps held for sale. Mr. Prud'homme was granted leave of absence from September 1 to November 1.

Mr. P. Frèreault compiled new surveys on the Nottaway River map and prepared the colour copy for the same. He traced and lettered for engraving and made the colour copy of a two-sheet map of the vicinity of Copper Cliff, Sudbury Mining District, Ont.; he traced the map of the Boundary Creek Mining district, B.C., the map of Blairmore-Frank coal-field, Alberta, and map-sheet No. 63, Nova Scotia. He has also lettered sheets Nos. 64, 75, 76, 82 and 83 N.S., for engraving and has drawn for reproduction by photo-lithography, the map of Northern Ontario and Eastern Keewatin and a small map, showing the recent land-slide near Buckingham, Que.

Mr. V. Pérrin at intervals, attended to the cataloguing of maps and plans, prepared lists of instruments requiring repairs and attended to general work. He traced the map of Pictou coal-field, N.S.,

for photo-lithographic reproduction and made sundry tracings of plans for office use. He is, at present, assisting Mr. Wm. McInnes in the compilation of the Ignace sheet (No. 5, Western Ontario), and in the preparation of a map of Winisk river, Keewatin, for the Summary Report.

Mr. J. A. Robert spent most of his time on the compilation of the series of one mile-to-the-inch sheets, covering part of Hants county, N.S. He revised the compilation of the map of Pictou coal-field, prepared the colour copies of several Nova Scotia sheets and traced the map of Springhill coal-field, N.S., for the lithographer. He has now in hand, the compilation of Mr. H. Fletcher's more recent surveys on the above-mentioned series of sheets, extending into Kings county.

Mr. O. O'Sullivan again accompanied Mr. W. J. Wilson in the field last summer. He spent some time in the preparation of his returns, plotting, etc., and continued the mapping of Mr. E. R. Faribault's surveys on the map-sheets covering Halifax county, Nova Scotia.

Mr. W. J. Wilson compiled a map of northern Ontario and Eastern Keewatin, showing his surveys of 1902, as well as those of Mr. D. B. Dowling of 1901, to accompany the report of last year. He left for the field on May 26 and returned on September 30. He is now preparing a map of last season's surveys for the present Summary Report. Having received a valuable set of plans of surveys which were required for the mapping of the Michipicoten mining region, Mr. Wilson will be able to resume the compilation of Dr. R. Bell's and his own surveys on sheet No. 143, Ontario, and carry it to completion without delay.

Mr. J. Keele completed his map of the MacMillan river exploration and resumed work on the Eastern Ontario map-sheets, laying down on the Ottawa and Cornwall sheet (No. 120) the surveys of Dr. R. W. Ells and of the late Mr. N. J. Giroux. Mr. Keele was on leave of absence from June 6 to November 1. Since his return he compiled a map of the Lake Temagami iron ore belts for Dr. A. E. Barlow's report.

Mr. W. H. Boyd completed the map of the Boundary Creek mining district, B.C., and left for the Lardeau mining camps, B.C. as topographer to Prof. R. W. Brock, on June 18. Since his return, October 5, he has spent his time in plotting his field notes, &c.

Mr. J. F. E. Johnston returned from sick-leave at the end of November and resumed the plotting of his surveys of 1902.

Routine work.

The routine work has, as usual, been distributed among the staff and attended to, but, as I mentioned in my last year's report, the assistance of an employée to have the care of the manuscript maps and other documents, surveying instruments, &c., to do typewriting and general work, is urgently needed. The draughtsmen have to spend much time on work which could be more profitably done by a general office assistant. The stock of many maps is being rapidly exhausted, particularly of those which cover the regions of northern and northwestern Ontario, and in the near future, new editions, brought up to date, will be required. Such editions, which often entail as much labour as new maps, would lead to the delay of other necessary work, unless provision is made with this in view. One or two more good draughtsmen are therefore required in this office to attend to map-compiling the year round, especially as Messrs. Wilson, Keele and O'Sullivan who will hereafter have charge of field parties, can devote only a small part of their time to mapping.

Geographic Board.

The meetings of the government Geographic Board have been regularly attended and, as usual, lists of place-names covering our maps now in progress have been submitted.

Accompanying maps.

The following ten maps, plans and sections, illustrating part of the progress made in the field during the past season, accompany the present Summary Report and Part AA, Annual Report, Volume XV :—

No. 842.—Map of part of the country between Peace and Athabaska rivers. Scale, 32 miles to 1 inch.

No. 845.—Sketch-map of the Cretaceous coal-bearing rocks at the headwaters of Sheep creek and Elbow river, Alberta. Scale, 2 miles to 1 inch.

* No. 846.—Exploration of the Winisk river and canoe-route from Fort Hope to Weibikwei or Winisk lake, Southern Keewatin. Scale, 16 miles to 1 inch.

* No. 847.—Explorations of the canoe-route from Montizambert station on the Canadian Pacific railway to English River Post on Kenogami river, and of the Little Current, Kebinakagami and Drowning rivers, Northern Ontario. Scale, 16 miles to 1 inch.

No. 848.—Plan of the recent land-slide on the Lièvre river, near Buckingham. Que. Scale, 12 chains to 1 inch.

No. 849.—Transverse section of West Lake mine, Mount Uniacke gold district, Hants county, N.S.

* Maps Nos. 846 and 847 accompany Part AA, in Vol. XV only.

No. 850.—Transverse section, Dolliver mine, Isaacs Harbour gold district, Guysborough county, N.S.

No. 852.—Map of the Northeast Arm and Vermilion iron ranges, Lake Temagami, Ont. Scale, 40 chains to 1 inch.

No. 853.—Index map, showing new exploration in the vicinity of Lardeau, B.C. Scale, 8 miles to 1 inch.

No. 862.—Map showing the older copper-bearing rocks of Southern Quebec. Scale, 10 miles to 1 inch.

Maps in progress.

There are, at present, twenty-three maps in the King's Printer's hands at various stages, including the geological West Kootenay sheet, the Apple River sheet, N.S., the Sudbury and Bancroft maps, Ont., and the Perth sheet, Ontario, of which the colour proofs have been revised and the edition is expected to be printed soon. In this number, are also included sheets Nos. 53, 59, 60, 61 and 62 of the Nova Scotia series and the map of the Klondike district which have been engraved, but the colour work is held over until the geological investigation in the fields covered by these sheets shall have been completed.

There are about thirty other maps under compilation in the office.

Field instruments.

The testing and repairing of field-instruments has been attended to, and the following new instruments have been purchased, viz.:—

One Hadley sextant, No. 8, from Cary, London, Eng.

One Folding Artificial Horizon, No. 13, from Cary, London.

Six Prismatic compasses and tripods, Nos. 71 to 76, from Cary, London.

One Zeiss monocular field-glass, No. 22, from Baush and Lomb, Rochester, N.Y.

Four surveying aneroid barometers Nos. 69 to 72, from Harrison & Co., Montreal.

One 66-feet steel tape, No. 15, from Keuffel & Esser, New York.

Two clinometer-compasses, Nos. 7 and 8, from Keuffel & Esser, New York.

One clinometer, No. 33, from Alex. Ross, Ponsonby, Que.

Two 66-feet Chesterman metallic tapes, Nos. 9 and 12, from Department of Stationery, Ottawa.

One Pocket Folding Kodak, No. 24, from W. J. Topley, Ottawa.

Two Premo cameras, Nos. 25 and 26, from W. J. Topley, Ottawa.

One Stück magnetometer, No. 1, from McGill University, Montreal.

Correspondence.

The number of letters, memoranda, specification sheets. etc., relating to map-work, was 240 sent, and 125 received.

Maps published.

An enumeration of the maps, plans, diagrams, &c., which were received from the printer during the calendar year, is appended herewith :—

Catalogue Number.	Description.	Area in Square Miles.
810	The Dominion of Canada, showing the progress of investigation by the Geological Survey of Canada, 1843–1903. Scale, 250 miles to 1 inch.	
805	Yukon—Explorations on MacMillan, Pelly and Stewart rivers. Scale, 8 miles to 1 inch.	
791	British Columbia—West Kootenay sheet (economic minerals and glacial striæ.) Scale, 4 miles to 1 inch	6,400
808	Alberta—The Blairmore-Frank coal-fields. Scale, 180 chains to an inch..	576
823	Assiniboia—Sections of Souris coal-field.	
804	Manitoba—Orographic map of the lower contour of Turtle mountain. Scale, 1½ miles to an inch.	
720	Western Ontario—Geological sheet No. 4 (Manitou Lake sheet.) Scale, 4 miles to an inch....................	3,456
814	Ontario and Keewatin—Explorations south-west of James Bay. Scale, 16 miles to 1 inch.	
775	Ontario—The Sudbury mining region (Victoria Mines map.) Scale, 1 mile to 1 inch	230
809	Ontario—Shore-lines of ancient great lakes. Scale, 24 miles to 1 inch	
750	Quebec and Ontario—Geological sheet No. 121 (Grenville sheet.) Scale, 4 miles to 1 inch....................	4,051
702	Quebec—Geological map of the Basin of Nottaway river. Scale, 10 miles to 1 inch.	
802	Quebec—Gaspé oil-fields. Scale, 2 miles to 1 inch.	
779, 780 & 781	Ungava and Quebec—Geological map of the east coasts of Hudson Bay and James Bay, sheets I., II. and III. Scale, 8 miles to 1 inch.	
801	Prince Edward Island—Geological outline map of P. E. Island and portions of adjacent provinces, showing anticlines. Scale, 16 miles to 1 inch.	
609	Nova Scotia—Geological sheet No. 46 (Pictou sheet.) Scale, 1 mile to 1 inch..	216
610	" Geological sheet No. 47 (Westville sheet). Scale, 1 mile to 1 inch..........	216
633	" Geological sheet No. 47 (Eastville sheet). Scale, 1 mile to 1 inch.................	216
635	" Geological sheet No. 56 (Shubenacadie sheet). Scale, 1 mile to 1 inch......	216
636	" Geological sheet No. 57 (Truro sheet). Scale, 1 mile to 1 inch.....	216
637	" Geological sheet No. 58 (Earltown sheet). Scale, 1 mile to 1 inch.......	216
812	" Preliminary geological map of Springhill coal fields. Scale, 50 chains to 1 inch....	113
806	" Sections of Bluenose gold mine.	
773	" Plan and section of Tangier gold district. Scale, 250 feet to 1 inch.	
	Also 8 diagrams showing the mineral production of Canada, 1902.	

PALÆONTOLOGY AND ZOOLOGY.

Dr. J. F. Whiteaves.

Dr. Whiteaves reports that for rather more than three months (102 days, exclusive of Sundays) he has performed the duties of Acting Deputy Head and Director, during Dr. Bell's two visits to Europe and subsequent short absence from Ottawa.

In addition to this, a preliminary report of a sub-committee of the "Committee on the Nomenclature of Geological formations in Canada," appointed especially to "consider the names of the various divisions of the whole sedimentary series in Canada, from the Archæan up to the Pleistocene," has been prepared and read before the fourth section of the Royal Society of Canada at one of its meetings in May last.

Collections of fossils studied.

A study of the rather large collections of fossils from the Silurian rocks of the Equan river and Sutton lake, Keewatin, made by Mr. D. B. Dowling in 1901, has been completed, and the manuscript of a detailed and descriptive list of the species represented in it has been furnished to Mr. Dowling for publication as an Appendix to his forthcoming report on the Geology of that part of Keewatin. Some sixty-one species of marine invertebrata are represented in these collections, and of these, forty two are identified or described, both specifically and generically, and nineteen only generically. A commencement has been made of a study of some collections of fossils from the Silurian rocks of the Winisk river, Keewatin, made by Mr. McInnes during the past summer.

Palæontological papers written.

Ten small consignments of fossils from the Corniferous limestone of Ontario have been received from the Rev. Thos. Nattress, of Amherstburg. These fossils have been determined as far as practicable and returned. A few pieces of rock from near Fernie, holding some rather obscure fossils, have been examined and the approximate horizon of this rock has been ascertained for the sender. The fossils are fragments of the guard of a belemnite, and the rock containing them is evidently either Jurassic or Cretaceous.

Six short papers, descriptive or illustrative of fossils of special interest in the Museum of the Survey, have been written and published during the year. The first of these is descriptive of a new species of *Cyrena* (*C. Albertensis*) from the Belly River series at Fossil Coulée, Milk River Ridge, Alberta. The second is a note on three recently received "Crania of Extinct Bisons from the Klondike Creek gravels." All three appear to be referable to the great Alaskan bison, *Bison*

crassicornis, Richardson, teste Lucas, (=*B. Alaskensis*, Rhoads) which seems to have been the progenitor of both the Wood and Prairie bison. The third is a description, with figures, of a new *Matheria* (*M. brevis*) from the Trenton limestone at Ottawa. Only two other species of this genus are known. The fourth records the recognition of a well marked specimen of the exclusively Jurassic ammonitoid genus *Cardioceras* in the Crows Nest coal fields, while the fifth and sixth are devoted to the elucidation of the Canadian fossils from the Black River limestone that have hitherto been referred to *Lituites undatus*.

Zoological work

At the request of Section IV of the Royal Society of Canada, a Bibliography of Canadian Zoology for the year 1902, exclusive of Entomology, was compiled and presented at one of its meetings in May last for publication in its Transactions.

A memorandum as to the number of species in the zoological collection of the Survey, and of photographs illustrative thereof, was prepared for Professor Macoun in February last. At that date, the collection consisted of at least one set, and in some cases of three or four sets, of the eggs of 266, since increased to 271 species or subspecies of Canadian birds, and of 82 photographs of the nests, etc., of some of them, amid their natural surroundings.

Apart from the extra correspondence necessitated by Dr. Bell's absence, the number of official letters received and answered has been about as usual.

Additions to museum collections by members of staff.

The following specimens have been received from members of the staff, or employées of the department, during the year 1903.

Ells, Dr. R. W. :—

About 200 fossils from the palæozoic rocks of Charlotte Co., N.B.

Chalmers, Dr. Robert :—

Three species of fresh water clams (*Unio complanatus*, *U. ventricosus* and *U. luteolus*) brought up by the Dominion government dredge from depths of 20 to 30 feet below the river level near the south shore of the St. Lawrence river at Sorel.

McInnes, W. :—

About 100 specimens of Silurian fossils from the Winisk River. 12 species of marine and fresh water shells from the Pleistocene deposits of the Winisk River, and about 50 specimens of fresh water shells from that river. Two arrow-heads and some chipped flints from Attawapishkat (or Lansdowne) lake.

Dowling, D. B. :—

28 Devonian and Carboniferous and Cretaceous fossils from the Cascade trough of the Rocky mountains.

Wilson, W. J. :—

28 specimens of Silurian fossils from the Kebinakami River, Northern Ontario.

Wilson, W. J., and O'Sullivan, O.:—

120 specimens of Silurian fossils from Little Current River, including a few that may be Cambro-Silurian ; and 37 Silurian fossils from Nagagami River, Northern Ontario.

O'Sullivan, O.:—

29 specimens of Silurian fossils from Drowning River, Northern Ontario.

Spreadborough, W.:—

Two sets of eggs of the American Magpie; and one set each of the eggs of the Pigmy Nuthatch, Californian Crow and Dusky Horned Owl, from Penticton, B.C.; and of the American Three toed Woodpecker from the Athabasca River.

125 skins of Birds and Mammals from Lake Okanagan, B.C., and 132 similar skins from the Peace River district.

The additions to the palæontological, zoological and archæological collections in the Museum during 1902, and from other sources, are as follows :— By presentation.

By presentation :—

(A.—Palæontology.)

Colonel C. C. Grant, Hamilton, Ont.:—

Numerous fine specimens of fossil polyzoa (bryosoa) from the Clinton and Niagara formations at Hamilton, and from the Niagara shales at Grimsby.

Dr. C. F. Newcombe, Victoria, B.C.:—

Fossil leaves from the Cretaceous rocks of the Queen Charlotte Islands; and a recent marine sponge from 300 fathoms off the West coast of those islands.

Walter Harvey, Crofton, B.C.:—

Two specimens of *Pholadomya subelongata*, Meek, from the Cretaceous rocks at Nanaimo, B.C. ; and four land shells from Crofton, R.C.

Rev. Thos. Nattress, Amherstburg, Ont.:—

Three fine specimens of a species of *Polypora* and seven fragments of a monticuliporoid, from the Corniferous limestone at Pelée island, Ont.

J. E. Narraway, Ottawa :—

Specimen of *Strophomena Billingsii*, Winchell and Schuchert, from the Trenton limestone at Hull.

T. C. Weston, Minneapolis, Min.:—

One fine specimen each of *Metoptoma Melissa* and *M. Hyrie*, from the Levis formation at Levis.

Dr. Cephas Guillet, Ottawa :—

Three specimens of *Cylichna alba* from the pleistocene clays at Odell's brickyard, Ottawa East.

(B. Zoology.)

Hon. William C. Edwards, Rockland, Ont.

Section of trunk of a large oak tree with the femur of a ruminant embedded in its heart.

C. H. Young, Hurdman's Bridge :—

Mounted specimen of the Screech Owl (*Megascops asio*).

Dr. Roughsedge, Ottawa :—

Six gastroliths of crayfish from Billings Bridge.

H. Harley Selwyn, Ottawa :—

Nest and set of four eggs of the Chimney Swift (*Chætura pelagica*) from Kirks Ferry, P.Q.

Miss Kirby, Ottawa :—

Hoary bat (*Atalpha cinerea*) caught at Gilmour and Hughson's mill, Hull.

Dr. James Fletcher, Ottawa :—

Live specimen of a large land snail (*Epiphragmophora fidelis*, Gray) from Comox, V.I.

N. Harry Meeking, Port Hope, Ont.:—

Set of three eggs of the Western Red-tailed Hawk (*Buteo borealis calurus*) from near Calgary, Alberta.

P. J. Keeley, Ottawa :—

Albino variety of the White-throated Sparrow, shot near Rockcliffe.

C. O. Senécal, Ottawa :—

Specimen of the White Undereving (*Catocala relicta*).

Olof. C. Hylander, Caribou, Maine :—

Named collection of the Fresh-water shells of Maine.

By purchase:

Large and perfect burnt clay pot of Indian manufacture found by Mr. James Lusk in the township of Eardley, lot 20, range xi, Co. Wright, August, 1903.

Brewer's Duck, male, shot near Thurso. A hybrid between the Black Duck and Mallard.

Set of nine eggs of the American Merganser (*Merganser Americanus*).

VERTEBRATE PALÆONTOLOGY.

Mr. Lawrence M. Lambe.

Mr. Lawrence Lambe reports as follows:—

Work by Mr. Lambe.

In continuation of the work of reporting on the collections of vertebrate remains in the possession of this department, and in accordance with instructions received, my time, during a considerable portion of the past year, has been devoted to a study of the dinosaurian *Dryptosaurus incrassatus* (Cope), from the Edmonton series of the Cretaceous system of the North-west Territories. The result of this work is intended to take the form of an illustrated quarto monograph to constitute the third part of volume III of Contributions to Canadian Palæontology in succession to the second part, which appeared in September, 1902, descriptive of the vertebrate fauna of the Belly River series. The manuscript for this monograph is more than half completed and the drawings intended for its illustration, forming seven full sized plates, are now ready.

The importance of a more intimate knowledge of the fauna of the Edmonton series is apparent when it is borne in mind that the beds of this series in Alberta constitute the principal coal-bearing horizon of the district.

Importance of Edmonton series.

As the Edmonton series is regarded as the equivalent of the St. Mary River series of the country to the south, and of the Wapiti River group of the Peace River district to the north, too much stress cannot be laid on the value of a thorough acquaintance with these beds. From an economic standpoint, as a horizon marker over a vast stretch of country to the east of the Rocky mountains, it is of the greatest importance.

At the request of the director of this department, Professor E. D. Cope of Philadelphia, published in 1892, a preliminary description of

two excellently preserved skulls of *Dryptosaurus* collected by Mr. J. B. Tyrrell and Mr. T. C. Weston, in 1884 and 1889 respectively, in the Red Deer River district in Alberta. The memoir now in course of preparation is intended to take the place of a further description of these remains, contemplated by Professor Cope, but prevented by his death.

Resignation of Professor Henry Fairfield Osborn.

It is to be sincerely regretted that the recent resignation of Professor Henry Fairfield Osborn, curator of the department of Vertebrate Palæontology of the American Museum of National History, New York, as an honorary member of the staff of the geological survey has to be recorded. The value of the co-operation of so eminent a scientist in the palæontological work of this department cannot be overestimated and the loss sustained by his much regretted withdrawal from active participation in that work, as honorary vertebrate palæontologist, is manifest.

During the months of February, March and April, a general study of the *vertebrata*, both fossil and living, was undertaken by me in New York at the American Museum of Natural History and at Columbia University under Professor Osborn. Special post-graduate courses at the latter institution were taken advantage of and every facility was given me at the American Museum for the study of the magnificent collection of vertebrate remains in its possession. Before returning to Ottawa the following museums were visited, U. S. National Museum, Washington, the Museum of Yale University, New Haven, Conn., the Museum of Princeton University, Princeton, N.J., and the Carnegie Institute, Pittsburg, Penn., and a special and careful examination was made of the extensive collections of vertebrates in each of these institutions. Thanks are due to the scientific heads of these museums for facilities afforded in the study of material in their care.

Collections of fossils named.

Collections of fossils, chiefly corals, have been named during the year, for different officers of the department for use in the determination of geological horizons, and similar collections have been named for outside collectors who sought like information.

Attention is directed to the desirability of mounting in a permanent and attractive manner those specimens of the vertebrate collections that have been recently described and figured, and of providing space for their exhibition to the public. A permanent mount in the case of all heavy or fragile specimens is necessary in anticipation of any movement to which such specimens may be subjected; otherwise the risk of irreparable injury is great, even with the most careful handling.

catalogue

A card catalogue of literature appertaining to vertebrate palæontology, with special reference to that of the Dominion, has been started and considerable progress made therewith.

Some time has been devoted to the study of vertebrates other than those of the Edmonton series, the results of which will be submitted for publication as occasion may permit.

The usual official correspondence in connection with the progress of the work on hand has been attended to, as in the past.

During the year the following papers have been published :—

'On *Stegoceras* and *Stereocephalus*,' Science, new series, vol xviii., p. 60.

'The lower jaw of *Dryptosaurus incrassatus* (Cope),' Ottawa Naturalist, vol. xvii., p. 133, with plates I, II and III.

BOTANY AND ORNITHOLOGY.

Professor John Macoun.

After handing in my summary report last December, I continued working on Part II of my Catalogue of Canadian Birds and before spring this was completed, the proof read and by the beginning of May it was ready for the binder. While reading the proof of this part, the material for Part III, which completes the work, was being put in shape and it will go to the printer early in 1904.

As an example of the notices of this work showing how it is appreciated in the United States, I give below the review of Part II in 'The Auk,' which is the official organ of the American Ornithological Union. The reviewer is the editor of the journal.

'The first part of this important work appeared in 1900, and its general character and scope were so fully indicated in this journal (vol. xvii, Oct., 1900, pp. 394, 395), that it remains now only to chronicle the appearance and extent of Part II, which includes the Raptores, and the succeeding families of the A. O. U. Check List to and including the Icteridæ. As in Part I, we have a compendium of the previously published information regarding the range and breeding areas of the species known to occur in North America north of the United States, supplemented by a large amount of hitherto unpublished material gathered by the members of the Canadian Geological Survey, and contributions from a large number of trustworthy correspondents. The authority is given for each record, whether published or unpublished, thus explicitly designating the sources of the information here presented. In the case of published records, the place of publication is often, but not always, explicitly stated. The 'Catalogue' also includes a list of the specimens in the Government Museum at Ottawa, with full data as to their place and date of capture, &c.'

'It is announced that Part III, completing the work, is ready for the press, and that it will be published during the coming winter. It will include such information relating to species mentioned in Parts I and II as may have been received since their publication, as well as an index to the three parts, and a complete bibliography of the authorities consulted in the preparation of the work. The 'Catalogue' will thus be a work of great permanent value, and a most important contribution to our knowledge of the distribution of North American birds.—J. A. A.'

Early in May, Mr. J. M. Macoun, my assistant, was instructed to proceed to Peace river and make an extended exploration there. His absence threw all the office work upon me, and hence the only field-

work I did this year was in the vicinity of Ottawa. For years I have been collecting material for my various publications and, amongst others, I am preparing one on Canadian Fungi, which, when issued, will be Part VIII of my Catalogue of Canadian Plants. For this reason my time was chiefly devoted to a study of the fungi in the vicinity of Ottawa. On account of our work having been always in the west, for the last 15 years, we have never had a complete series of the Ottawa plants in our herbarium; so this year I collected over 900 species and only about 300 others are necessary to complete our local collection.

For the last 15 years we have been gathering the material for a catalogue of Canadian mammals, and at present have over 1,000 skins of the smaller mammals from nearly every section of the country. Towards spring I purpose putting these in order and hope to publish a "Catalogue of Canadian Mammals" in the winter of 1904–05.

By an arrangement with you, Miss Stewart works half her time for me and the other half for the librarian, so that about 15 hours per week is the limit of her services for me. This, taken into consideration with the increasing work of the office, leaves very little time to either myself or my assistant for original work. Owing to our widening field of labour and the amount of material requiring distribution, it is absolutely necessary that I should have more clerical assistance if much greater progress is to be made with our work. A great deal of the time of both my assistant and myself is taken up by work that could be done by an intelligent person whose services were entirely at our disposal.

My assistant, Mr. James M. Macoun, was occupied in field-work for more than five months. The remainder of the year was spent by him in the office, where his time was devoted to the study of material brought by him from British Columbia in 1901 and 1902. All the plants added to the herbarium were studied and named by him and the greater part of the botanical work of my branch is now under his charge.

About 3,000 specimens of plants for the herbarium were received from correspondents, the largest collection being a duplicate set of Engelmann's plants from the St. Louis Botanical Gardens. The number of flowering plants mounted and placed in the herbarium was 2,133 which brings the total up to 60,648. Only 1,427 sheets of specimens were sent out in exchange, as Miss Stewart had not the time to label more.

Eight hundred and ten official letters were written during the year and about the same number received.

THE LIBRARY.

Dr. John Thorburn, Librarian.

During the past year, from January 2 to December 31, 1903, there have been distributed 15,693 publications of the Geological Survey, comprising reports, parts of reports, special reports and maps. Of these 12,397 were distributed in Canada; the remainder, 3,296, in foreign countries, as exchanges, to Universities, Scientific and Literary Institutions and to a number of individuals engaged in scientific pursuits.

The sales of publications, during the above period, including reports and maps, amounted to $727.22.

There were received as donations or exchanges to the library, 3,300 publications, including reports, transactions, proceedings, memoirs, periodicals, pamphlets and maps. Publications purchased, 136; scientific periodicals subscribed for, 42. The number of letters received in connection with the library was 2,260, besides 2,750 acknowledgments from exchanges and individuals for publications sent to them. The number of letters sent from the library was 1,739, besides 629 acknow ledgements for publications received. There are now in the library about 13,700 volumes, besides a large number of pamphlets. The number of volumes bound was 219.

A large number of the earlier reports and maps are now out of print and can no longer be supplied.

As has been frequently stated, the space available for library purposes has hitherto been altogether insufficient, causing a large amount of unnecessary labour and time in finding information. During the past summer an additional room has been fitted up to relieve the pressure. This will be a great convenience for those having occasion to consult the books.

It may be stated that the library is open for consultation by persons wishing to obtain information in regard to scientific subjects.

VISITORS TO THE MUSEUM.

The number of visitors who signed the museum register during the year was 27,837.

STAFF, APPROPRIATION, EXPENDITURE AND CORRESPONDENCE.

The staff at present employed numbers 57.

During the year the following changes took place in the permanent staff:—

Mr. Albert P. Low re-appointed a technical officer.

Mr. Thomas Burke, caretaker, died.

Mr. James A. McGee appointed a junior second class clerk.

Mr. John F. Lyons appointed caretaker.

The funds available for the work and the expenditure of the department during the fiscal year ending June 30, 1903, were:—

Details.	Grant.	Expenditure.
	$ cts.	$ cts.
Civil list appropriation	54,275 45	
General appropriations	78,866 73	
Civil list salaries		50,806 83
Explorations and surveys		23,815 10
Wages of temporary employees		24,570 30
Printing and lithographing		27,496 93
Purchase of books and instruments		1,569 40
" chemicals and apparatus		660 09
" specimens		93 18
Stationery, mapping material and King's Printer		1,417 91
Incidental and other expenses		3,361 34
Advances to explorers		10,545 00
		144,336 08
Deduct paid in 1901-02 on account of 1902-03		14,782 99
		129,553 09
Unexpended balance civil list appropriation		3,468 62
" general "		120 47
	133,142 18	133,142 18

The correspondence of the department shows a total of 7,970 letters sent, and 10,764 received.

I have the honour to be, Sir,

Your obedient servant,

ROBERT BELL,

Acting Deputy Head and Director.

January 1, 1904.

APPENDIX.

The following thirteen samples from the Klondike district were assayed for gold by Mr. M. F. Connor.

No. 1. Sample marked Skookum gulch: White subtranslucent quartz with vitreo-resinous lustre; weight of sample, 1 lb. 4 oz.

It contained no gold.

No. 2. From Lepine creek, marked 'Billy Button'; weight of sample, 1 lb. An association of non-stained quartz with a little feldspar.

It contained gold, a decided trace.

No. 3. Normans creek (Chisholm's claim); sample weighed 14 ozs., composed mainly of quartz with brown stains of iron oxide.

It contained gold, a trace.

No. 4. Lepine creek (claim of Cornelius Lowney); sample weighed 13¼ ounces. An association of quartz with sericite schist coloured deep brown by iron oxide.

It contained gold, a trace.

No. 5. Sample marked 'Violet Group,' and composed of quartz with slight iron stains; weight of sample, 1 lb.

It contained gold, a trace.

No. 6. McKinnon creek (Britannia mine); sample of quartz-conglomerate weighing 1 lb.

It contained no gold.

No. 7. Reuter creek (Great Eastern); weight of sample, 14 ozs. An altered sericite schist.

It contained gold, a decided trace.

No. 8. Sample marked 'Great Eastern Dyke'; weight of sample 1 lb. A highly altered feldspathic rock.

It contained gold, a decided trace.

No. 9. Marked 'Spotted Fawn' ore; a sample weighing 12 ozs. A dark grey quartzite.

It contained no gold.

No. 10. From head of Victoria gulch; a sample weighing 1 lb. 2 ozs. Mainly quartz (with cubes and grains of pyrites) associated with sericite schist.

It contained gold, a decided trace.

No. 11. Lepine creek (Tupper claim); sample weighing 1 lb. 5 ozs. Mainly quartz with a little sericite schist.

It contained no gold.

No. 12. From McKinnon creek, sample marked 'Blue Rock,' a blue quartz; weight of sample, 10 ounces.

It contained no gold.

No. 13. From Hunker creek, below Gold-bottom; weight of sample, 1½ ounces. An association of quartz, feldspar and a little calcite; the mass stained with iron oxide.

It contained gold, a trace.

D. B. D., photo. 1902.

HASSARD AND NEW SOURIS MINES.

D. B. D , photo. 1902.

NEW SOURIS MINE.

GEOLOGICAL SURVEY OF CANADA

ROBERT BELL, Sc.D. (Cantab.), M.D., LL.D., F.R.S., I.S.O.

REPORT

ON THE

COAL FIELD OF THE SOURIS RIVER

EASTERN ASSINIBOIA

BY

D. B. DOWLING, B.Ap.Sc.

OTTAWA
PRINTED BY S. E. DAWSON, PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1904

15—F. No. 786.

To Dr. ROBERT BELL,

Acting Director, Geological Survey of Canada.

SIR,—I have the honour to submit the inclosed report on investigations conducted during part of the summer of 1902 in the Coal Field of the Souris river. To illustrate the report, I have made to scale a model showing the surface features of the region from Estevan eastward to a point beyond the coal mines, and photographs of this are submitted for reproduction. A few photographs of natural features and sections also accompany this report, as well as sections plotted to show the probable trend of the different coal seams.

I have the honour to be, Sir,

Your obedient servant,

D. B. DOWLING.

Ottawa, April 29, 1903.

SUMMARY OF CONTENTS

ILLUSTRATIONS.

REPORT

ON THE

COAL FIELD OF THE SOURIS RIVER

EASTERN ASSINIBOIA

By D. B. DOWLING.

GENERAL FEATURES OF SOURIS COAL FIELD.

The actual area over which the coal-bearing rocks of this district extend, is not exactly known, principally because there are so few exposures in the stream valleys, on account of an extra thickness of surface deposits, eastward from the area now mined. This great mantle of drift consisting of boulder-clay extends northward through the Moose mountains and is continued north of the Assiniboine river. It has concealed the eastern outcrop of the coal rocks and their extension can be learned only by boring. At Oxbow a deep well for the water-supply of the town had penetrated sandstone at 230 feet below the surface and small particles of coaly matter came up in the overflow pipe. This indicates their eastward extension to at least the mouth of Moose Mountain creek. The lower land between that creek and Turtle mountain is probably eroded to beneath this horizon. Westward it is supposed that the Tertiary coal-bearing rocks extend to the Coteau and also occupy the summit of Wood mountain. General features.

Along the face of the Coteau extends a wide flat which is drained at present both to the northwest and southeast by parallel streams which appear to have a very slight fall. Moosejaw creek heads in the Yellowgrass marsh near the head also of the Souris river. The elevation of the surface at the nearest railway station, 1889 feet, is not very much above that at Estevan or Pasqua, so that this strip may be said to be a nearly level plain bordered on both sides by a slight rise. The only deep river valley cutting into this is that of the Souris river and its main branch Long creek. From the north Plain drained by Souris.

Drainage.

the drainage has as yet cut only a short valley from the Qu'Appelle to near Moose Jaw with a fall in that distance of 135 feet. This northward drainage seems therefore to be much more recent than that to the south and suggests than the drainage area of the Souris has been reduced by a later tilting of the plain by a slight depression to the north. Evidence of the late depression is more pronounced in the western part of the plains in Alberta, but on the other hand in Manitoba the latest crustal movement is an elevation to the north, so that in this area the movement has been slight in either direction and, as noted above, probably the northern part has been slightly depressesd.

Denudation of valleys

The main valley of the old drainage is now occupied by Long creek as shown on the maps, but a slight depression just to the east of the Coteau carries another stream which joins the large valley opposite Estevan. This carries about the same or even less water than Long creek and is called Souris, although it would seem that the other should have had the name. This part of the Souris has cut a very narrow and short valley above its junction with the large one at Estevan. Evidence of the very level nature of the surface drained is seen in the shifting of the channel which led from the edge of the plain into the valley, causing a series of parallel lateral valleys on the north side above Roche Percée. Many of these lateral gorges were eroded by companion streams which have gradually lost their water supply by the deepening of the channel of the main stream. Several small isolated hills in the valley remain to show the former continuance of the side walls of these companion valleys.

Side gullies.

South of the Souris and east of Short creek there is a decided rise in the surface amounting to about 100 feet above the general prairie level. From this to the bed of the river there is a fall of 240 feet in a distance of only two miles and as the rocks underlying the surface are very friable they are easily eroded and the drainage of this slope has excavated a number of very large and wide gullies which have dissected a broad area. On the north side the banks below Roche Percée are high and where the lower coal seam is being mined are intersected by narrow steep cuts which are taken advantage of in getting at the seam.

Width and depth of valley.

South of Estevan the valley is wide and is in fact a double valley, about a mile and a half wide and 110 feet deep. At the mines it is less than a mile in width and over 130 feet in depth. The river-flat is well grassed and a fringe of trees skirts the stream. Many ox-bow lakes show the gradual shifting of the channel by cutting off bends.

D. B. D., photo. 1902.

NATURAL EXPOSURE CLAYS AND SANDS JUST ABOVE LOWER COALS ON SEC. 13, TP. 2, R. 8.

D. B. D., photo. 1902.

WEATHERED SANDSTONE, SEC. 13, TP. 2, R. 8.

THE COAL HORIZONS.

The coal seams exposed in the district are many but in the small area here described they may be grouped in three horizons—Upper, Middle and Lower. Each of these may contain several seams but in each, workable seams occur at places.

Upper Horizon.

Upper seams.

This contains generally a four feet seam that is fairly continuous throughout the district except where eroded away by the streams or, as on Short creek, where it either thins out or is joined by the seams of the middle horizon to form a seven feet seam. The coal seams are separated by deposits of sand and clay that are very variable in their thickness and areal distribution—measures that are prominent in some sections being absent in others so that a series of small seams may, by the absence of these partings, be brought into one. The upper horizon has been prospected in the vicinity of Estevan at several points and though the coal is generally an inferior lignite it serves for local use. The first mine opened in the district was on this upper seam, locally thickened to eight feet or thereabouts. On the hillside just south of the town, several thin seams are exposed, probably of the upper and middle horizons, but they are very poor and only a part of each seam is utilized. Another opening on this seam is on the edge of a ravine near the cemetery where a tunnel shows the thickness to be about four feet. No other exposure of this horizon was noted for some distance to the eastward and it is again well exposed in a ravine north of the Taylor mine. It has there been mined in several places and being near the prairie-level the coal was easily teamed northward to some of the stations on the railway. Above the Souris and Roche Percée mines it is still in evidence and is opened in several places. On Sec. 35 it was reached in the bore-hole at about 50 feet from the surface but is somewhat lower in the exposure near the river. A tunnel on Sec. 6, of the township to the east, is on the same seam at a higher level than in the bore-hole. The sections accompanying this report are drawn to scale so that the position of the seams can be measured, but as a rule the absolute heights are given in the text along with the descriptions of the sections. In referring to the sections it will be seen that along the north side of the river the upper coal is probably continued at a distance from the immediate brink of the valley and may undulate slightly. Near the eastern end of the field there seems to be a very pronounced wave in the beds below, and probably the upper seam follows the same curve. The

North bank of river.

sections across the large valley and up the smaller ones *i.e.* from the Taylor mine up Short creek, and from the Soo mine up the Souris, show firstly that on Short creek there is a depression to the south whereby the upper and middle seams are brought together and secondly that on the upper part of the Souris the upper seam rises slightly to the south.

Middle Horizon.

North side of river.

Along the north side of the valley this horizon is found to be exposed in several places but shows a great tendency to thin out in places and east of the mines it is hardly discernible. The isolated hill west of Estevan, in which a tunnel has been run is probably a representative of this horizon. There the coal is split up into three seams—the lower one only being mined. Again on the face of the hill south of the town a four feet seam slightly lower in elevation is its probable representative. Above the Soo mine a three feet seam of coal and shale at 1790 feet is probably of the middle horizon. Farther east it is doubtful whether the seam in the Duncan mine belongs to this or the lower horizon and may be the burnt seam that is exposed at the top of the bank in the south-east corner of Sec. 14. A seam that was on fire in the north-east corner of Sec. 6 of the next township to the east may belong to the middle group. A valley to the north of this would deflect the outcrop to the north leaving a long oblong hill with a portion of this coal near its top. Burnt shales indicate feebly its presence along the bank to near the mouth of Short creek. An exposure at one of the bends of the river shows four feet of burnt shale, indicating a burnt seam of fair thickness and as it is about at the proper elevation for this horizon it is so marked on the section. In the ravine north of the Taylor mine at an elevation of 1807 feet there has been a tunnel driven on a 3 ft. 6 in. seam which is below the upper coal but eastward from this the seam becomes insignificant and split up by partings. In the Hassard mine there is a two feet seam at this horizon, but this, is represented in the Sugar Loaf section, by two seams of a foot each, separated by a foot of gray clay. No trace of lignite is found farther east on the north bank.

In the sonthward bend of the upper part of the Souris, the middle seam takes a prominent place and is found well up the bank near the larger valley with a thickness of six feet. Good exposures are rare in this part but it is found near Wood End in a seven feet seam and the percentage of fixed carbon left by fast cooking shows that it is of as good quality there as the average of the coals of the valley. On Short creek, as before mentioned, there is a thinning out of the measures

between the middle and upper coals and they seem to come together. Several short tunnels have been run into the banks to extract coal from this seam and apparently the supply has been required by settlers of the immediate vicinity and across the boundary line. There is a slight rise in the measures to the east so as to bring up the seam again on the east branch of this creek in Sec. 6 near the International boundary.

Lower Horizon.

North side of river.

This is the most important in the district, as in it the lower seams are of better quality as a rule than any in the upper horizons. In the western end of the district there are several small seams, occasionally of workable thickness but east of the mouth of Short creek these are gathered together in an eight feet seam that is being mined on a much larger scale than near Estevan. West of the mouth of Short creek the outcrop of the seams is low down in the valley and most of it would be below the river flat, but it is probable that it has been eroded close to the sides of the valley and the river flat filled with river deposit. The dip of the seams in this lower horizon is not very constant in any direction. The section shows a considerable wave at the east end on the north side of the valley with a general tendency to become lower to the west. South from the mines the outcrop seems to be below its position on the north and this southward dip is further proved in a boring on Sec. 10, in which the seam is found at 20 feet above its position in the bore on Sec. 35. This may however only mean that the crown of the anticline in the seam at the Souris and Roche Percée mines is continued in a N.N.E. direction. This if produced southward will pass through Sec. 5 near the boundary and bring up the middle and upper seams that go below the valley-bottom at the conical hill at the mouth of the east branch.

South from Estevan.

In the upper part of the valley, south from Estevan, the lower horizon rises slightly and is found higher up the river than expected. In the bed of the stream on Sec. 22 the lower coal was seen for the last time in that direction. Near Estevan exposures of the lowest part of this horizon are seen on the south border of Sec. 14. Up the valley toward the town the measures rise slightly and beds, probably of this horizon, are found low down in the banks as at the Soo mine. On the south side of the valley a mine is opened in the south-east corner of Sec. 11 on two seams of five and six feet thickness that are somewhat higher above the river-bed than those of the same horizon northward, but in the section given on Sec. 10 it is found again split up into several small ones.

South side of river.

Very few exposures were seen between the bend of the Souris and the mouth of Short creek, but interested parties who have probably sunk test pits report that there are several valuable seams at accessible locations in this part of the valley. A mile west of the mouth of Short creek on Sec. 35 there is an exposure of a five feet seam near the water of the creek. This is not all pure lignite as the lower part is very dirty, but a short distance to the east it is split up into two seams—the lower, two feet three inches thick, being of a very fair quality of lignite which on coking leaves 38.90 per cent of fixed carbon.

At the mines.

The other exposures that occur east of this are those only that are at the mines. In the Taylor mine the seam is five feet with a small seam below. In the Hassard the parting gradually thins out towards the east, and across the ravine in the New Souris mine there is a thickness of eight feet of lignite. In the workings this occasionally thickens up to a maximum of twelve feet for short distances. In the Roche Percée mine the seam is about eight feet and in the bore-hole on Sec. 35 there were seven feet six inches. East of this no trace of the lower coal has been found by the miners. At one locality on the south side of the river on Sec. 28, at the mouth of a gully, the lower seam was found and some coal was extracted, but as it was low down it is probable that the water interfered with the workings.

Lowest seam.

In the bore-hole put down by Dr. Selwyn on the side of the valley in Sec. 6 he probably did not strike any of these, but was able to demonstrate that there is yet another seam much lower down in the series, that may by the undulations of the beds be found nearer the surface in places to the north and on the river eastward, that have been generally considered nonproductive.

Burning of Coal seams.

Burning of seams.

Enquiries made at the mines have elicited the information that in the vicinity, the burning of the seams extends at farthest only about one hundred feet, back from the bank. The cause of the seams catching fire at the surface can generally be traced to the drying out and disintegrating of the lignite at the outcrop rendering it easily kindled. The ignited mass slowly extends farther into the bank drying by its heat the upper part of the seam which is first consumed as far back as the lack of moisture allows. The further consumption of the lower part proceeds very slowly before it is extinguished.

Mines operating.

During the summer many of the mines are not in operation as the market for the product of smaller ones is purely local and the demand only for the winter months. In the Estevan district there was only one (the Duncan mine) that was shipping coal by car lots. This was drawn by team to a spur or siding on the bank above. The mine is not developed to any extent, as yet only four rooms, two on each side of the entrance, being mined out and the timbering required is not very extensive. Of the Soo mine, which is said to be worked in the winter, no information as to the character of the workings could be obtained as the slope was flooded with water. Many open cuts along the side hill are to be seen near the town where farmers have dug up coal for home use. Across the valley on Sec. 11 a tunnel is driven into the bank on a six feet seam and a slope farther in leads down to a lower seam, said to be five feet thick. As the tunnel was not well timbered part of the roof had fallen and the interior was not seen. About two miles up the Souris from the bend, a tunnel is being dug into the hill on the west side of the valley, probably on the middle seam. Duncan mine. Prospect tunnels.

The Souris Coal Co., which now has control of the mines working at Coal Field east of Roche Percée, has for the present closed up the Taylor mine near the latter station and confined its operations to the group known as the Hassard, New Souris, Farmer and the Roche Percée mines. These are all on an eight feet seam. The entrance to the Hassard is from the west side of the gully in the southern part of Sec. 4 As the seam has an easy slope to the west, the entrance is on a slight incline and the drainage of the mine is accomplished by a steam plant which also compresses air for the cutting machines. In the New Souris mine the entrance is to the east and just opposite the Hassard. In this the seam is reached by a short slope and as it rises slightly toward the north-east the loaded cars require very little power to haul them to the foot of the slope. The drainage is very simple and might be said to be natural. In the Roche Percée mine the entrance is from the level and the seam for a short distance, rises slightly and then runs on nearly a level, with perhaps a slight fall to the north-east. The drainage is principally by a siphon to the mouth but an adit-level has been cut eastward to the next gully. Mines at Coal Field P. O.

The system of mining is generally by the room and pillar method. Double entries from the foot of the slope or from near the entrance are driven with a width of about six feet, leaving a pillar of at least twenty feet between them. Side entries run from the main ones and System of mining.

from these the rooms are opened about twenty feet wide with a pillar of the same width.

Ventilation.

The ventilation is induced by chimneys opening to the surface of the prairie above, in which a fire is kept burning and the circulation of air is controlled by a system of doors on the entries and small tunnels from these to the rooms.

Timbering.

Timbering in the entries is made close, but in the rooms it is found that a double row of posts at six feet apart is sufficient, the roof though generally of soft sandstone does not fall suddenly and often a thin roof of coal is left, as it is brittle and by cracking warns the miner. In parts of the mines where the seam is very wet, the entries are extended so as to cut out large areas and the block is allowed a season to drain out.

Amount and character of coal.

Character.

As the coal is a lignite, its physical condition renders it difficult to transport without loss from both slacking and crushing. Its chemical composition shows not only a high percentage of water but also of volatile combustible matter. The water is readily lost to a large extent by exposure to the air so that it is generally shipped in closed box cars and care is also taken in storing it in a closed shed. The loss of the moisture causes it to crack and the poorer part is reduced to powder.

In the mining the friable nature of this coal causes also a large loss by waste in the process, so that instead of a cubic content of twenty-five feet making a ton it is more generally found that at least thirty feet are necessary and in parts of a seam a higher percentage of loss ensues. If the miner could extract all the coal in the mine at even this percentage of loss there would still be for this eight feet seam a total of 10,890 tons to the square acre or for the square mile 6,969,600 tons. This amount is all that can be expected from the one seam, but for local use there are several seams as outlined previously, above the one at present being mined and the total supply can thus be greatly added to.

Amount of coal.

Lignites of plains.

In a general way the lignites of the plains, in beds not disturbed by lateral pressure or folding, are very similar, but it is found by analysis that the percentage of fixed carbon decreases eastward from the mountains. A few examples are here tabulated to show the fairly general tendency. The samples are from natural exposures.

1 Turtle mountain, Dakota, fixed carbon 36·90 Bull. U.S. Geo. Surv. No. 27 p. 74.
2 Souris river, Sutherlands tunnel, carbon 38·64 Report of Pro. 1882-83-84 11M.

3 Hay flat, Wood mountain, carbon 38·54 Annual Report 1885 3M.
4 Main seam, Mine 7 miles W. of Medicine Hat, carbon 41·58. Annual Rep. 1885 1M.
5 Coal banks, near Lethbridge, carbon 47·91 Report of Progress 1882-83-84 30M.
6 North edge of Milk river ridge near Fossil coulee, carbon 49·85. Ann. Rep. 1885 5M.
7 North fork of Old Man river at base of Rocky mountains, carbon 58-40. Report of Progress 1882-83-84 33M.
8 South fork of Old Man river, carbon 57·50. Annual Report 1885 9M.
9 Cascade mine, Bow river, carbon 74·35. Report of Progress 1882-83-84 41M.

Nos. 7, 8 and 9 are true coals—the last one being a semi-anthracite.

Increase of carbon with depth below surface.

In a general way the lower seams or those having a greater thickness of strata above them are better in character than those nearer the surface. This is shown in several analyses made by Dr. Dawson of the seams exposed on Sec. 10, south of Estevan, and given in paragraph 210 in the International boundary report. The members of the section are numbered from the top downward.

No. 2 is a lignite having 30·10 per cent of fixed carbon.

No. 10 is a lignite having 36·68 per cent of fixed carbon.

No. 17. A weathered specimen (percentage low) 28·01.

No. 19. Lignite (weathered) 38·35 per cent fixed carbon.

In following the seam, given above as No. 2, up the valley to the south, it becomes covered by a greater thickness of strata and near Wood End an analysis shows 34·97 per cent fixed carbon. Many of the seams show a tendency to change in character—sometimes indeed passing into a dark shale with hardly a trace of carbon.

Age of the deposits.

Age of deposits.

From the fossil remains collected at different times from this locality, it has been generally recognized that these beds are directly comparable with the Fort Union group. In the Edmonton district of northern Alberta, the beds which were referred to the Laramie are divided into two series, the lower deposited in brackish water and the upper in fresh water. The upper series, the Paskapoo, contains a fauna that is certainly very similar to that found in the Souris and may therefore be correlated with it. The Souris rocks are thus probably situated at the base of the Tertiary and above the upper part of the transition series at the top of the Cretaceous.

The division drawn between the upper and lower parts of the Laramie probably comes below the coal seams of the district, and the lower part comparable to the Edmonton beds is to be found in the section given in the bore-hole put down by Dr. Selwyn east of the mines. The coal

horizon reached by this bore at about 300 feet, probably represents that which is repeated in the lower slopes of Turtle mountain in Manitoba and again to the west in the western part of the Coteau and the Wood mountains.

This would show a wide shallow syncline along the International boundary, the centre of which, showing the highest beds, being in the neighborhood of the mines at Roche Percée—the high plateau east of Short creek and the eastern part of the Coteau.

Fossils.

The horizon at which most of the fossils were found is above the lower coal seams which are here exposed and many of them come from the beds between the upper and middle horizons. The plants are from the shales above the lower coal.

The following forms are compiled from the lists already published:

Unio priscus, M. and H.
Corbula mactriformis, M. and H.
Thaumastus limnæiformis M. and H.
Goniobasis Nebrascensis, M. and H.
Goniobasis tenuicarinata, M. and H.
Campeloma productum, White.
Campeloma multilineatum, M. and H.
Viviparus trochiformis, M. and H.
Viviparus Leai, M. and H.
Viviparus Conradi ?

PLANTS.

Platanus heterophyllus, Newberry
Platanus nobilis, Newberry.
Sassafras Selwyni, Dawson.
Quercus. Sp.
Taxites Olriki, Heer.
Taxites occidentalis, Newberry.

Beside the above we made a collection of plants which are not yet determined, as well as a small collection, mainly the same forms as in the above list; and from just above the lower coal a claw of a turtle and a vertebra, probably of a reptile of the type of Champsosaurus were obtained.

D. B. D., photo. 1902.

THE SUGAR LOAF HILL, SOURIS MINES.

D. B. D., photo. 1902.

WEATHERED SANDSTONE, SOUTH SIDE OF SOURIS VALLEY.

NATURAL EXPOSURES AND SECTIONS

North side of valley from Estevan eastward.

Dominion mine.

Just west of the station yard at Estevan, the railway crosses a deep gully running west to the valley of the Souris. In this the first extensive work of extracting coal was begun in what was called the old Dominion mine. This was on the upper seam, which is generally found to be about four feet in thickness over a large part of this area. Here however it had a thickness of about eight feet but the quality proving poor the enterprise was abandoned. As the old workings are blocked up the only exposures now to be seen are in a small tunnel about one hundred yards west of the trestle, running into the south bank. Here the seam is eight feet but very dirty looking—a bright part about ten inches thick near the top being the only good coal in the section. On the northern side of the gully the old entrances to the levels of the Dominion mine still stand though the railway tracks that formed a spu rdown the coulee have been removed. From all appearances the seam worked was of a friable nature and very dusty. It is only about twenty feet below the surface in the vicinity of the town. The elevation by comparison with the rails at the station is 1830 to 1838 feet above tide.

Section in valley west of Estevan.

In the valley to the south this seam is not well exposed as the slopes are mainly grass covered. On the slopes of an isolated hill almost south of the old mine several of the upper seams are well exposed. The upper four foot seam is represented by a few streaks of lignite. Below this the middle seams, which along the valley are generally burnt at the outcrop, are here represented by quite important beds. The section in the hill is given below.

	Feet	in.	Approx. Elevation.
Clay	6	0	Top of hill 1847
Lignite thin streaks			1841
Clay	16	0	
			Top of coal 1825
Lignite	1	6	
Clay	2	6	
Lignite	1	0	
Clay	2	0	
Lignite	3	6	
			Bottom of section 1814

Near the north end of this, another level has been excavated into the hill to strike the same bed but it had been burnt out.

Coal seams beneath Estevan.

On the edge of the bank south of Estevan station and near the post marking the conjunction of the four sections numbered 14, 15, 22 and 23, a ravine cuts into the bank for a short distance leaving a projecting point in section 15. On both sides of this point the upper and middle coal seams are exposed. On the west side the upper seam has been opened along its outcrop and considerable coal taken out without mining. Here the elevation of the seam is 1825 feet above sea. The seam, probably the one at the Dominion mine, contains only 17 inches of fair coal covered by two feet of carbonaceous shale almost a lignite.

On the eastern edge of this point the same seam is again exposed with a covering of light clay six feet in thickness to the top of the bank. Below there is grey clay for eight feet to the top of another small seam. Yellow sandy clay with ironstone nodules occurs at the bottom of this exposure below the last coal seam. South of this section and above the road leading down from the town, at 1810 feet or 16 feet below the upper seam there is an exposure of four feet of poor dusty lignite of which only the lowest foot appears to be fairly hard. Grey clay five feet in thickness lies below this and then another small lignite seam is seen. The beds beneath the road leading out of the coulee ought to be on the horizon of the seams at the Soo mine in the next ravine to the east.

The section here can be summarized as below :—

	Feet	in.	Approx. Elevation.
Light grey clay.......	6	0	Top of bank 1836
Lignite...	4	0	Base of seam 1826
Grey clay......................	8	0	
Thin seam of lignite......... . .		1	 1818
Yellow clay and sand	4	0	
Lignite.........	4	0	Base of seam 1810
Grey clay...	5	0	
Measures concealed........... .	2	0	
Lignite 1 ft quarried......	1	0	Concealed to foot of slope 1780

Sec. 14, Tp. 2, R. 8.

The north-east quarter of Sec. 14 is cut up by a large coulee opening southward at the centre of the section. The exposures in this show the heaviest coal horizon to be at about the lowest part or floor of the area thus eroded. On the outer edge of the banks as they approach the river valley there appears to be a slight dip to the south-west so as to carry the coal seams beneath the river flat. This may mean, however, that the coal is burnt out along the edge of the valley and into the banks to the north, so letting down the top measures five or six feet. On the north side of the amphitheatre here formed is the

Soo mine. A sloping tunnel leads down from the foot of a scarped bank and coal has been mined here by Mr. Yardley. Nearer the railway, in a narrow valley, an upper seam has been opened by prospect holes near the surface. It has there a thickness of 4½ feet but it is soft and dusty and would not bear much transhipment. Soo mine.

The section here is as follows:—

	Feet.	in.	Approx. Elevation.
Grassy slope, measures concealed......	11	0	Top of hill 1833
Lignite, seam exposed in ravine.......	4	0	Base of seam 1817½
Gray clay with sandy streaks of lignite..........................	11	0	
Gray clay.........	5	6	
Yellow streak........................			
Gray and yellow sandy clay..........	6	0	
Ironstone nodules....................			
Gray clay.....	2	0	
Lignite and shale....	3	0	
Sandstone...........	7	6	
Clay ironstone layer..................			
Lignite	1	6	
Black shale........		8	
Lignite		10	
Clay and sand....	4	6	
Lignite, seam being mined by Mr. Yardley.........................	3	6	Top of coal 1775

In the next side gully east from the Soo mine, probably on the northern part of the south-west quarter of Sec. 14, an opening has been made at nearly the same level as at the Soo mine, by Mr. P. Duncan. Here the partings between the three lower seams have disappeared and nearly eight feet of coal is being mined. The slope extends into the hill about two chains, and two rooms have been extended back about forty feet from the tunnel on each side. The face of the seam shows a fair quality of lignite, with a dull portion in the centre—the lower part being of better quality. A roof of more than a foot of the coal is left and about six feet and a half is taken out. This is being shipped in car lots—the transfer from the mine being made by team to a spur on the railway above the mine. Duncan mine.

The top of the coal seam is at about 1781 feet above sea or nearly on a level with the top of the three lower seams at the Soo mine.

The south-west quarter of Sec. 14 is homesteaded by Mr. M. Carroll and is mostly a broad river flat. In the southern part two isolated hills are being cut into by the stream along their south side and three seams are exposed. The lower one is of fair coal about four feet Carrolls mine.

in thickness and it has been mined to some extent. The spring floods almost reach the mouth of the tunnel but it is generally about 15 feet above the stream. Above this four feet seam which appears to be a lignite of fair average quality, the section shows 1 foot of yellow sandy clay followed by 18 inches of poorer lignite. A variable amount from 28 in. to 24 in. of light clay showing sections of stems and pieces of carbonized wood is above the middle seam and a thickness of 14 in. of poor coal represents the upper part of this coal horizon. In tracing this upper seam around the hill it appears to thin out considerably. Above the coal is five feet of clay, at the top of which is a clay ironstone layer. The ironstone is found at the eastern end of the hill at two feet above the coal so that the intervening clay deposit is very variable in thickness. The ironstone is covered by clays and sands to the top of the hill, about 25 feet.

Southern corner of sections 13-14.

The river makes a strong bend to the east and touches the south-west part of Section 13. A high point at the extreme south-west corner is scarped and shows a section of nearly 57 feet. The faint exposures along the banks from Estevan eastward would seem to indicate that the same beds were exposed all along. If the coal seams found here an the same as at the Soo mine, there must be a slight dip to the east amounting to forty feet from the mine to the south-eastern corner of the same section which will be seen on a comparison of the elevation given for the two sections. The section at this place is given below in descending order.

	Ft. in.	Elevation. Ft. in.
Top of exposure		1791 0
Yellow sandstone overlying burnt shale, beneath which is a series of sands arranged in bands yellow and grey	27 0	
Lignite	1 0	
Clay light grey	3 6	
Ironstone band		
Sandy clay	6 6	
Clay ironstone		
Clay and ironstone	9	
Lignite	1 0	
Clay	1 0	
Lignite one foot to fifteen inches	1 3	
Sandy clay	4 6	
Top of coal seam		1744.6
Lignite	1 6	
Covered to water	8 6	
Estimated level of water in river		1734.0

In the lower part, now concealed by a landslide, there is evidence to show that coal has been mined here, but the spring freshets flood the workings and drag down more of the cliff. It is reported that the farmers open up a four-feet seam that comes above the water-level at that season each winter. It is probably a seam which is partly covered by the present stream in flood.

Strata on the north part of Sec. 12 just south of the half mile mound, in descending order : Sec. 12, Tp. 2, R. 8.

	Ft.	in.	Elevation. Ft.
Top of section			1797
Grey clay and rusty pebbles	20	08	
Yellow clay with a streak of ironstone nodules at bottom	20	0	
Dark carbonaceous shale	1	0	
Grey clay	6	0	
Clay ironstone band			
Lignite		6	
Measures concealed	8	0	
Lignite	1	0	
White sandstones	5	9	
Lignite, thickness unknown			
Slope covered to water	6	3	
Level of river			1730

A grass-covered valley with steep slope runs parallel to the river. This depression extends from Sec. 33 to the town of Estevan and thus forms a narrow ridge between it and the river. Side valleys cutting directly back from the river have begun the gradual dissection of the ridge into long hills, a process which can be seen at a later stage in the lines of small ridges in the larger valley.

Exposures are not frequent along this part but a small section is shown in a hill in the north east part of Sec. 6, township 2, range 7, where one of the side gullies is cutting across the narrow ridge. Sec. 6, Tp. 2, R. 7.

	Ft.	in.	Elevation. Ft.
Top of exposure			1810
Yellow sandstone			
Top of coal seam on fire			1788
Lignite approximate thickness	6	0	

A small conical hill just here has had the coal seam which formed its top burned away. Below this a clay ironstone band appears at 1775 feet.

The section under it is :

Sec. 6, Tp. 2, R. 7.

	Ft.	in.	Elevation. Ft.
Top of clay ironstone			1775
Grey clay with yellow streaks	2	0	
Poor Lignite and black shale	1	0	
Sand	1	0	
Black shale	2	0	
Bottom of exposure			1769

Section on river bank in Sec. 5, township 2, range 7 :

Directly south from the centre of the section on the river bank a small exposure shows three small seams near the water. At 1803 feet, the top of the exposure, yellow sands and clays with a few beds hardened into sandstone form the mass of the upper 30 feet. At 1773 feet or 30 feet down, a broad red band shows where the coal seam noted a mile up the river as being on fire, has been burned out. Gray clays show to 1742 feet or 12 feet above the water, underlaid by three small coal seams.

Sec. 3, Tp. 2, R. 7.

Section on south-west corner, Sec. 3, township 2, range 7.

Beds altogether above those exposed in the last section are here seen and the horizon of the upper coal should be exposed. It may probably be represented by two thin seams in the upper part of the section.

	Feet	in.	Approx. elevation.
Prairie level			1850
Clay and small fragments of ironstone	5	0	
Gray clay	6	0	
Black carbonaceous shale	0	8	
Brown shale partly lignite	1	0	
Light yellow sandy clay	6	0	
Bright yellow to orange sandy clay partly sandstone	2	0	
Lignite	0	2	
Brown and gray clay	4	0	
Yellow sandstone and clay-ironstone	3	0	
Gray clay	2	6	
Yellow clay-ironstone and thin bedded clays	2	0	
Whitish gray sandstone	2	0	
Base of exposure			1815
	34	4	

Exposure on south-east part of Sec. 35, township 1, range 7.

The upper beds of the exposure given above are not repeated between this and Roche Percée as the banks are much too low near the river

and the outcrop would probably follow north of the township line. A dry valley parallel to the present one affords an easy grade for the railway out of the valley on the north side. The point thus cut off is not as high as the average of the banks elsewhere. A bend of the river cutting into it affords a good exposure of the lower beds. The top of the exposure commences near the base of the one above and may include some of it The following is the section in descending order :— Sec. 35, Tp. 1, R. 7.

	Feet	in.	Approx. elevation.
Surface			about. 1817
Boulder clay and surface deposit	2	0	
Brown sandstone	2	0	
Gray clay	8	0	
Sandstones	6	0	
Clay with shells	12	0	
Red burnt shales	4	0	
Supposed lignite seam			1783
Yellow and blue clay	6	0	
Gray sandy shale	2	0	
Yellow sandstone	3	0	
Gray sandstones with dark clay at top	6	0	
Gray clay with streak of lignite at top	4	6	
Sandstone	2	0	
Gray clay, red streak at top	9	0	
Dark gray clay, brown at top	6	0	
Lignite much weathered, with streaks of clay near base	5	0	
Concealed to water of stream	10	0	1730
	87	6	

The burned seam at 1783 appears at the right elevation for a continuation of the seam noted as being on fire in Sec. 6, about four miles to the west. It is impossible to be certain without sections closer together international but the beds seem to be undisturbed. The exposure are continued along the bank to Sec. 25. The references to these in the Internatonal boundary report are in the following paragraph :—

'207 sections more or less perfect are exhibited in many places in the Souris valley, a mile or two west of the entrance into it, from the south, of Short creek; and more especially on the north side of the valley. They show a great similarity, though not absolutely the same in any two places.

'One of the most perfect exposures seen was in the face of a bank from sixty to seventy feet high, and consisted of sand, sandy clays, and hard fine clays very regularly and perfectly stratified, and coloured in various shades of yellow-gray, gray, and light drab. At two differ-

Sec. 25, Tp. 1 R. 7. ent levels harder sandstone layers of small thickness were seen and also three distinct beds of lignite.

"The lowest is a hard compact lignite resembling cannel coal in aspect, and two feet three inches thick. A few feet above this a second seam, eighteen inches thick, occurs, and still higher in the series, and about half way up the bank, a third, of the same thickness. At the top of the bank some large nearly spherical nodules rest, and have evidently been derived from a superior bed which has been removed by denudation. The clays and arenaceous shales, at several different levels include remains of mollusca, but these are very fragmentary, having been crushed by the compression of the containing material. A species of Unio is abundant, and remains of gasteropoda also occur, though rarely, and in poor preservation."

Sec. 31, Tp. 1, R. 6. Eastward and north of Roche Percée station the exposures are not very distinct but the coal seams of the lower horizon appear to rise slightly and at the Taylor mine in the south-east corner of Sec. 31, township 1, range 6. a thickness of five feet of good lignite is mined - Taylor mine. 28 feet above the water of the stream. Above the coal is a well defined band of sandstone weathering out along the top of the hill in irregular forms. This sandstone band can be traced from the middle of the section given above and is between the lower coal and the burnt seam of the middle of the exposure. The full section at the Taylor mine is found to be represented north along the banks of a small stream. In the mouth of a valley coming from Sec. 5, a well shows a section of about 25 feet of sandstone above water and it probably reached downward to within 10 or 15 feet of the coal seam of the mine.

The total section in the side valley and the mine could be represented by the following scheme :—

	Feet	in.	Elevation. Above tide
Surface of prairie south edge of Sec. 5..			1862 6
Surface deposit	4	0	
Yellow sandstone	2	0	
Yellow clay	4	6	
Lignite partly burned at outcrop, mined at several points in the valley	4	0	
Level of floor of tunnel			1848
Whitish clay with some sandstone.	8	0	
Light yellowish clays and sands.	12	0	
Lignite		6	
Bluish clays with several carbonaceous layers	6	0	
Brown sandy ironstone	1	0	
Drab clays, darker streaks of lignite	1	0	....

	Feet	in.	Elevation above tide.	
Base of exposure..			1819	6
Concealed to top of coal seam min'd nearby	8	0	1811	6
Coal, lignite.........................	3	6		
Concealed to curb of well at about	8	0		
Sandstones in well, at least.............	25	0		
Sandstones exposed above the Taylor seam	14	0		
Top of coal at mine near river..........			1761	
Lignite, Taylor seam....................	5	0		
Clays &c., to water of stream.	28	0		

Mr. Thompson the former manager of the Taylor mine informs me that in drilling by hand below the seam of the mine another seam of 22 inches of lignite was found and that for a considerable depth below that seam the measures were barren. This would agree with the record of the bore put down by Dr. Selwyn six miles to the east.

East of this there is a group of mines now in active operation on an eight feet seam which appears to be a continuation and combination of the seams of the lower horizon. In the Walsh mine there is reported a clay parting which is first developed in the Hassard mine just to the north. In this latter mine the seam dips to the west and the clay parting increases in that direction. To the east in the New Souris mine there is no clay parting and the seam maintains a thicknessof eight feet and sometimes considerably exceeds that volume. The same may be said of the seam in the other mines to the east. There seems to be no doubt that the coal splits in going westward. This is also borne out in the sections near Estevan where this horizon is represented by several thin seams.

Mines on sections 33 & 34, Tp. 1,. R. 6.

Lower seam split by clay parting.

The section in the vicinity of the mines is well represented by the exposures on the steep hill east of the Walsh mine called the Sugar Loaf. The group of mines are all on the one seam and it is noted that there is a considerable difference in elevation at the several localities indicating an undulation of some magnitude. The following elevations arranged in order from the west will serve to show this :—

Undulation in beds at mines.

	Elevation. 8 ft. seam. Feet.	4 ft. seam. Feet.
Taylor mine.......	1756	1848
Sugar Loaf.....	1768	1837
Souris mine..	1766	1839
Farmer mine......	1790	
Roche Percée mine	1797	
Trial pit east of mine...................	1788	
Bore hole on Sec. 35............	1752	1812
Trial pit on Sec. 6 east..		1823

That the seam slopes up to the north is shown in the bore made on the south east corner of Sec. 10. Here the elevations are, for the lower seam about 1783 and for the upper one 1848 or only 14 feet below the surface, while on Sec. 14 the upper one was not found at all, probably reaching the surface between the two places.

Section of the strata in the Sugar Loaf.

Sugar Loaf section at mines.

	Feet	in.	Elevation.
Surface			1855
Soil	0	6	
Yellow sandy clays	5	5	
Streak of lignite	0	2	
Sandy clay with concretions and ironstone	7	5	
Lignite	4	6	
Clay and brown shale	1	10	
Sandstone	2	2	
Yellow clay some lignite	2	6	
Yellow sandstone	3	10	
Lignite	1	0	
Dark clay	1	0	
Light yellow sandstone	7	5	
Streak of lignite	0	4	
Yellow and gray clay	3	0	
Top of middle seam			1814
Lignite	1	0	
Gray clay	1	3	
Lignite	0	7	
Gray clay	6	11	
Lignite	0	3	
Gray clay shale	0	6	
Yellow to brown sandstone	1	6	
Yellow and gray clay	2	0	
Drab clay and shale	1	0	
Yellow clay	0	4	
Gray clay	1	3	
Carbonaceous clay	2	0	
Dark clay	2	6	
Dark clay with streaks of lignite	3	7	
Lignite	0	6	
Gray clay	1	0	
Yellow and gray sandy clay, with thin sandstone beds hardened 3 in.	7	10	
Shaly lignite	1	0	
Clay	3	0	
Top of lower coal			1776
Coal seam	8	0	
	86	6	

At the Souris mine the coal is overlaid by sandstone in most of the exposures. Occasionally the roof is clay. Below the eight feet seam in

the Souris, another, two feet in thickness, is exposed at about five feet below, on the road between the Souris and the Farmer mine.

The eight feet seam has proved to be of a fair quality of lignite, and its thickness is ample to admit of economical working. It has been traced along the face of the valley on the north side from the Walsh mine to Sec. 35, and the bore put down near the centre of this section in 1902 proved its existence there, but east of this it has not been found. The levels given above show that in this part its surface is undulating; and eastward from the bore it is expected to dip to the east and go below the surface of the river-flat. Reducing the elevations to show the height above the bridge, crossing the river at the mines, will more clearly show the amount of rise and fall of the seam at its outcrop. At the Taylor mine it is about 18 feet above the bridge —at the Souris mine 40 feet—at the Farmer mine 64 feet—at Roche Percée mine 71 feet—at trial pit east of above mine 62 feet—at bore on Sec. 35, 26 feet. It is thus seen to be descending rapidly to the east from the latter point and it was looked for at an exposure on Sec. 36, a mile east of the bore-hole.

The 8 foot seam.

Undulations.

The river there cuts the bank and exposes over 100 feet. At the lower part are several holes made by the miners in trying to locate the lower seam apparently without success. The measures are not very well shown but the following section was made out:—

Sec. 36, Tp. 1, R. 6.

	Feet	In.	Elevation Above tide.
Top of point slightly back from the brink			1858
Concealed by grassy slope	20	0	
Sandstones partly hardened	56	0	
Top of upper coal seam			1782
Lignite	4	0	
Light gray clay and some sand	36	0	
Darker gray clay	24	0	
Concealed to river	6	0	
Water of river			1712

The upper seam is here only 66 feet above the river and to the north east in Sec. 6 at a distance of about a mile it has risen to 115 feet above the stream. This is probably the direction of the greatest dip. The lower seam might be expected to be present in the bank below this exposure, but more likely too low down to work. East of this it probably rises and might be found by digging, but the superficial deposits are found to be much more thickly strewn over the sides of the valley as well as on the upper surface, so that there are no exposures and the effort of individual miners is not equal to overcoming the increased thickness of this bouldery mixture.

SECTIONS ON SOUTHERN BANK OF SOURIS RIVER.

As the river here makes a bend to the north-east the sections on the south side should indicate the continuance of the seams a short distance. None of these exposures show the lower seam, but the best section is that given by Dr. Selwyn in St. Peters gully. This is probably the one that cuts through the eastern part of Sec. 25, township 1, range 6, judging from sketches in his note book. His barometer reading along the face of the bank and on the prairie above would place his lower seam at 63 feet above the Souris. Comparing this with the section I have given across the stream on the north bank, where the upper 4 feet seam is at 66 feet above the water, I am inclined to think that the lower coal of his section is the 4 feet seam above the one at the mines.

Sec. 25, Tp. 1, R. 6.

Reducing the elevations to the known positions of the stream and the top of the bank, the section should be placed as below:—

St. Peters gully.

Dr. Selwyn's section, St. Peters gully.

	Feet.	in.	Above tide.
Top of bank			1751
Soil and sandy clay	10	6	
Lignite	3	0	
Base of coal			1836
Soft drab sandstone	9	0	
Ironstone band	0	8	
Soft drab sandstone	8	4	
Lignite	0	8	
Base of coal			1819
Sandy clay shale	8	0	
Ironstone with clay shale	1	6	
Sandy shale	8	4	
Sandy shale with carbonaceous streaks	2	0	
Sandstone and concretionary sandrock with ferruginous bands and concretions.	9	0	
Clay shales	5	0	
Carbonaceous streak	1	6	
Clay shales, sandy	5	0	
Ironstone and shale	2	0	
Lignite (underlaid by stiff clay shale)	3	0	
Bottom of seam			1775
	76	6	

Range 5.

While boring near here in 1880, Dr. Selwyn made an effort to trace these seams eastward to near the site of the bore-hole. His notes show that this seam rises rapidly to the north-east and that in the well section there was no chance of striking this series. The outcrops are all concealed, but by sinking a pit in the centre of Sec. 31, a seam

of lignite 3′ 3″ was uncovered at 103 feet above the stream. This Dr. Selwyn assumed to be the middle seam of the section above, and so expected to strike it just above the bore-hole farther east. The top seam he traced a short distance and supposed that it runs out to the surface. It is more probable however that this was the lower seam of his section and so would show about the same rate of rise as in the same seam on the north bank. The elevations for these localities, assuming all to belong to one seam are:— Rise of seams to east.

St. Peters gully	63	ft. above	river
Centre of Sec. 36	66	"	"
Centre of Sec. 31	103	"	"
Trial pit on Sec. 6	115	"	"

These elevations do not allow of a single plane passing through them all, but show a rise to the north-east increasing north of the line joining the second and third of the list above. Leaving out the first and projecting the plane passing through the others to the site of the bore-hole in the south-east corner of Sec. 6, township 2, range 5, it is found that the plane shou'd there be at 138 feet above the river. This is near the top of the bank and taking the distance below that at which the lower 8 feet seam was found in the bore on Sec. 35, it would bring the probable position of the lower seam 86 feet above the river. Probable position of seams at bore-hole of 1880.

Both these heights are above the mouth of the bore and of a well or pit sunk by hand to strike the seam. The elevations here reduced to sea level are:— Sec. 6, Tp. 2, R. 5.

	Feet.
Water of stream	1708
Surface at bore-hole	1767
Surface at pit 13 feet deep	1791
Estimated position of 8 feet seam	1794
Estimated position of upper 4 feet seam	1846
Top of bank	1854

The bore was sunk to a depth of 295 feet and at 272 feet or 1495 feet above tide, a seam six feet thick was reached. The details of this drilling are given in Dr. Selwyn's report for that year.*

The character of the coal is given in the same volume p. 8H. For the sake of comparison with others of this field it is here repeated.

"Analyses by slow and fast coking gave the following results:—

* Report of Progress Geol. Surv. Can. 1879-80, p. 8A

Coal from bore-hole.

	Slow coking.	Fast coking.
Hygroscopic water	17·78	17·78
Volatile combustible matter	29·51	32·70
Fixed carbon	44·36	41·17
Ash	8·35	8·35
	100 00	100 00

Ratio of volatile combustible matter to fixed carbon 1 to 1.50 1 to 1.26

Upper seam south of river. On the south side of the river the exposures, with the exception of that given for St. Peters gully are not generally so easily made out. Coal has been mined on Sec. 26 in one of the gullies, probably from the seam represented in the lower part of the St. Peter section. A good exposure of this is seen in the railway cutting at the south-eastern corner of Sec. 34. Four feet six inches is the thickness at this point at an elevation for the bottom of the seam, of 103 feet above the bridge or 1829 feet above sea.

In the large branching side valley on Sec. 27 traces of this seam are seen occasionally at about this same elevation all around the eastern part. To the west it lowers somewhat and in the next depression which in plan is roughly leaf-shaped, it is being mined from an exposure on the hillside in Sec. 28 at an elevation of about 83 feet above the bridge. Along the south side of the main valley this seam, west of the long trestle, is not exposed but probably runs along above the railway cutting. A small seam is exposed in the cutting at about 70 feet above the river showing a slight dip to the west. This is probably represented in the Sugar Loaf by one of the middle seams.

Pure Lignite mine. The upper seam where mined on Sec. 28 is from 50 to 56 inches thick and is of very good appearance. The section here is not very extensive, only 27 feet of beds being seen.

Section at Knight and Carlson's Pure Lignite mine, N. W. quarter Sec. 28, Tp. 1, R. 6.

	Feet	In.	Above tide.
Drab and yellowish clay at top			1819
Light yellow clay	4	0	
Dark gray clay	2	0	
Lignite	4	4	
Base of coal			1809
Sandstone	12	0	
Gray clay	4	0	
Lignite	0	10	
Bottom of exposure			1792
	26	10	

Burnt shales on the sides of the hills surrounding this large denuded tract indicate a former outcrop of this seam. But where these lines surround isolated hills it is probable that most of the coal has been burned away.

The sandstones below the seam which show along the side of the valley to the west and near Roche Percée are irregularly hardened so as to weather out in castellated forms so well described by Dr. Dawson, in the extract which follows ; Roche Percée.

* 'On the south side of the Souris valley, and a short distance to the east of the valley of Short creek, the Roche Percée group of rocks is situated.

'This locality has already been described by Dr. Hector and Captain Palliser who made a branch expedition to it from the north, in August 1857, being induced to do so by the reports of Indians and halfbreeds. These remarkable rocks which have long been objects of superstition to the Indians inhabiting the surrounding country, owe their curious forms to the weathering away of a soft gray sandstone from below a bed of similar rock which weathers yellow and is rendered durable by an abundant calcareous cement. Both the upper and lower sandstones show false-bedded structure in great perfection ; though that in the upper hard portion, is on a smaller scale, owing to the thinner divisional planes of the rock. The capping sandstone is not hardened in a perfectly uniform manner, but in belts several yards in width, lying parallel in a northwest and southeast direction, and separated by spaces more easy of disintegration. There is also a system of cross-jointing nearly at right angles to this main direction.'

'This combination of structure has given rise, under the long continued action of the weather, to the remarkably castellated, fantastic and picturesque rock scenery of this part of the Souris valley. The hard belts form tongues projecting diagonally from the grass-covered bank, and the erosion of the underlying soft sandstone, parallel to the cross joints, has, in several places produced window-like openings through them. The soft rock bears in many places rude Indian carvings, representing various animals and birds, strings of beads, etc."

The only trace of the lower seam was in the mouth of the gully at the northwest corner of Sec. 28 below the Pure Lignite mine on the upper seam. It is at about the level of the small stream which here crosses the railway and has been opened and probably mined for Lower seam south of river.

* Report on the Geology and Resources of the forty-ninth parallel by G. M. Dawson, Montreal, 1875, p. 86.

a short time, but as it is so low the water of the stream probably flooded the workings. Its elevation here is only three feet above the bridge or 1729 above sea.

Mouth of Short creek.

Following the slopes west to the mouth of Short creek, the upper and middle seams are occasionally indicated by burned shales but no certain line of outcrop can be made out. It is very probable, however, that they are represented in the section at the mouth of the creek at Sutherlands mining location, measured by Dr. Selwyn in 1880. The exposure occurs at a sharp bend in the stream as it emerges from the narrow valley of Short creek and cuts into the east bank. The face of the bank is being rapidly eroded and slides are frequent, concealing the natural section. As the bank is only 90 feet high the section published by Dr. Selwyn is puzzling as it totals over 150 feet. This might be explained by supposing that the figures are in links and chains and also measured on the slope of the bank. Reduced as in the following it would agree better with what I was able to make out of the original section.

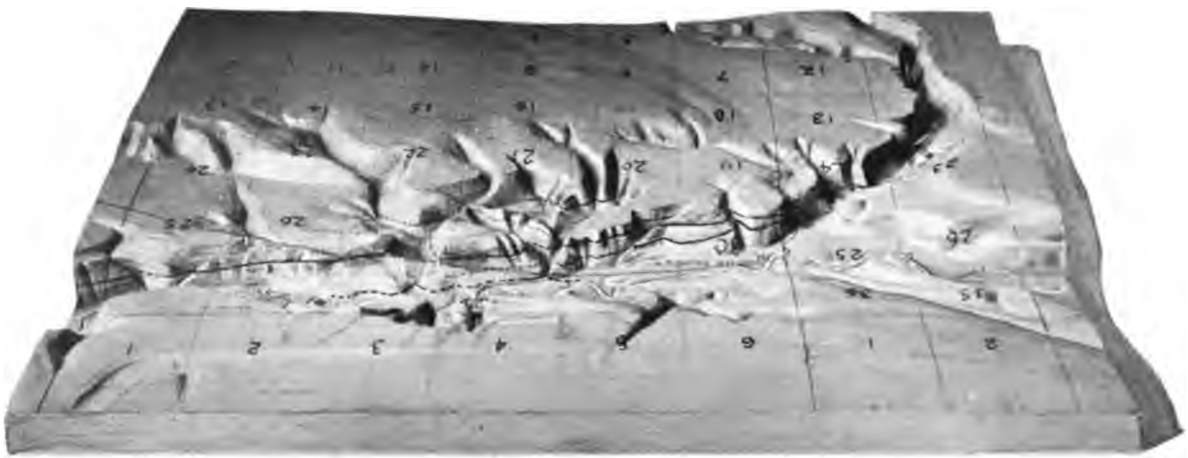
	Feet.	in.
1 Soil and superficial drift	4	0
2 Sandstone or sandy clay	6	0
3 *Lignite*	2	0
4 Dark drab plastic, clay shales	1	0
5 *Lignite*	5	0
6 Whitish soft sandstone	32	0
7 *Lignite*	3	0
8 Soft brown sandstone	11	0
9 Whitey brown sandstone (containing ironstone layer 6 to 7 feet thick in which were collected fossil leaves)	32	0
	96	0

Sutherland's tunnel.

Several tons of coal were taken from a tunnel on the five feet seam in 1880 and shipped to Winnipeg, probably the first shipment of coal from this valley. A tunnel 78 feet in length having been driven, the coal was loaded upon barges and sent down the then swollen stream. Dr. Selwyn says of the coal ;—* 'In the tunnel the lignite appeared to be solid and of good quality. The upper seam is only between 15 and 20 feet below the prairie level, and thus slight depressions in the surface would suffice to have caused its removal.' An analysis of this lignite was subsequently made in the laboratory of the Survey by Dr. Hoffmann who furnished the following report.†

* Report of Progress Geol. Surv. Can., 1879-80 p. 5A.

† Report of Progress Geol. Surv. Can., 1879-80 p. 9H.



PERSPECTIVE OF MODEL, LOOKING SOUTH. SHORT-CREEK AND GULLIES SOUTH OF MINES. FROM MODEL OF COAL FIELDS.
UPPER, MIDDLE AND LOWER COAL SEAMS.

'A brownish black, compact lignite, ligneous texture very marked; lustre for the greater part dull, in more altered parts sub-resinous to resinous; tough; fracture on the whole uneven, occasionally, however, verging on the sub-conchoidal; does not soil the fingers, powder black, with a brownish tinge; it communicates a deep brownish red colour to a boiling solution of caustic potash; by exposure to the air becomes more or less fissured. Coal of Upper horizon.

Specific gravity 1.4168—Weight of one solid cubic foot 88.55 pounds.

Analyses by slow and fast coking gave as follows:—

	Slow coking.	Fast coking.
Hygroscopic water	21·84	21·84
Volatile combustible matter	32·15	35·12
Fixed carbon	41·61	38·64
Ash	4·40	4·40
	100 00	100 00
Coke, per cent	46 02	43 04
Ratio of volatile combustible matter to fixed carbon	1 to 1·29,	1 to 1·10

Short Creek.

Up the valley of Short creek several of the exposures show good sections of the rocks and coal seams. The first one of which I made an examination is on the south-west side of a long point running to the south-east from the north-west corner of Sec. 24. A section measured by Dr. Dawson near the crossing place of the Commission trail, must be near this, as the sequence of beds is very similar. The trail ascends the west bank and gains the prairie level near the cut-bank. The section as measured by Dr. Dawson is as below. Sec. 24, Tp. 1 R. 7.

	Feet	in.	Approx. elev.
1 Soil	1	6	1840
2 Yellowish coherent sand, gray externally, and holding some much broken Unio-like shells at its base	12	6	
3 Gray clay	2	10	
4 Yellowish and thin bedded sands and sandy clays, with several very thin ironstone layers, weathering orange-red externally	6	0	
5 Gray clay	2	4	
6 Similar to No. 4 with decayed fragments of gastero-pod shells	12	0	

	Feet.	in.	Approx. elev.
7 Also similar to No. 4 but with a great number of thin ironstone sheets..........	3	0	
8 Hard yellowish sandy clay, a few inches at the top carbonaceous..........	10	0	
9 Good hard *lignite*..........	2	2	
10 Hard yellowish sandy clay..........	2	7	
11 Good lignite..........	4	9	
12 Grayish sand and sandy clay, showing lines of stratification; in some places soft and incoherent, in others with large concretions, and sometimes forming a nearly solid sandstone..........	9	0	
13 Hard gray clay..........	2	0	
14 Grayish-yellow clay, with many thin layers of orange-weathering ironstone..........	3	0	
15 Lignite..........	2	6	
16 Greyish and yellowish hard sand and sandy clay...	11	0	
Section concealed by slope of detritus, about.....	12	0	
	99	2	1740

To show the change in composition of beds, in even a short distance, the section measured in possibly the same bank near its eastern end is added below. The top beds bear the same general resemblance with perhaps an addition of another bed of sandstone at the top.

		Feet.	in.
No. 8 of above section	—Yellowish sandstone weathering very light, 5 to..........	6	0
No. 9 of above section	*Lignite*..........	0	6
	Brown carbonaceous shale..........	2	6
No. 10 " "	—Yellowish sandy clay..........	5	0
No. 11 " "	—*Lignite*..........	5	2
No. 12 " "	Greyish sand and sandy clay..........	6	0
	Sandstone concretions..........	2	0
No. 13 " "	—Yellowish sandy clay..........	6	0
No. 14 " "	—Gray clay with lignite streak at top...	1	9
No. 15 " "	—*Lignite*..........	3	4
No. 16 " "	—Concealed to water of stream, about...	10	0

The beds of this section were recognized in the field as bearing a great resemblance to those in the large gully on Secs. 28 and 29, and the seam at the Pure Lignite mine was then correlated with the one in the section numbered 11. This would also be the 5 feet seam at the mouth of the river, at Sutherland's tunnel. The lower seam does not again appear in any section above this on the creek. The others were traced to the mouth of the eastern branch—being then in the bed of the creek.

On Sec. 23 the seams are disclosed by a line of red burnt shale running on both sides at about the same elevation as on Sec. 24. Sandstone is seen in harder beds above the coal on the west bank and farther up the stream. A settler living on the north-east quarter of Sec. 14 has been digging in the bank for coal with poor success. First he opened a hole on the upper thin seam and it was very poor in quality. Again he started lower down and reached the horizon of the larger seam but it was all burnt out in the small hill in which he was digging. Under the steeper bank the burning probably will be found not to have penetrated very far. The burnt clays are at about 20 feet above the river. Secs. 14 & 23, Tp. 1, R. 7.

In Sec. 11 there is a good exposure on the eastern bank. Near the water, a resident settler has opened a tunnel on the thicker seam and taken out coal for local use. The thickness of the seam is here seven feet and the coal appears to be of as good quality as most of that mined in the district. Sec. 11, Tp. 1, R. 7.

The following is a section of the beds :—

	Feet.	in.	Approx. elev.
Surface deposit about	2	0	1870
Clays and clay ironstones	5	0	
Clay and sand	5	6	
Brown and gray clays with streak of lignite at top	4	0	
Brown and gray streaks of sandy clay with dark streak at top	5	0	
Yellow and brown clays with streaks of ironstone	3	0	
Dark brown shale	0	3	
Sandstone	12	0	
Gray and dark yellow clays, a few bands of red ironstone	22	0	
Small streak of lignite	0	6	
Yellow sandstone not very much hardened	25	0	
Lignite	1	6	
Gray clay	2	9	
Lignite	7	2	
Gray clay	3	0	
Lignite	0	4	
Clay to water of stream	2	0	
	101	0	1770

In this the thickness of the main seam is greater than farther down the stream. The elevation above the water, only 5 feet, brings it below the general level of the river flat and the danger of flooding in the spring is much greater.

At the junction of Short creek and its eastern branch, a conical hill is situated in the centre of the branch and on the eastern edge of the larger valley. The waters of both streams nearly join above the hill but are deflected to the north. In high water the larger stream divides around the hill. In the channel thus made an outcrop of coal was discovered, being part of the thick seam of the section given just above. Only five feet of it could be made out, as the remainder, if any, was beneath the water of a pool. Three feet were above water and two or more below. In the banks, sandstones are exposed in almost the same section as farther up the east branch. Both north and south the clays at the bottom of the bank are reddened where the coal has been burnt.

Sections on the east branch of Short creek.

Grassy slopes conceal most of the rocks with the exception of two or three exposures where the sandstones are slightly harder and form steeper slopes. The first noted is at the southeast corner of Sec. 11 where the following order was observed :—

Sec. 11, Tp. 1, R. 7.

	Feet.	in.	Feet
Top of bank			1870 above tide
Concealed by grassy slope	18	0	
Yellowish sandstone and streaks of clay	20	0	
Yellowish clay with a few sandy streaks.	20	0	
Thin ironstone band lying on false bedded sandy clays	0	3	
Gray clays with Unio shells, top sandy	12	0	
Lignite	1	0	
Clay, gray to light yellow	4	0	
Sandstone to water of stream	10	0	
Elevation of water of stream about			1785
	85	3	

Sec. 6, Tp. 1, R. 7. The next exposure is at the centre of Sec. 6 on the north bank where sandy clays show in the bank, and 45 feet down, a tunnel is opened on a fair coal seam. In the tunnel the coal is from 57 to 60 inches thick with a clay parting of 8 inches separating it below from a smaller seam of 10 inches. The tunnel is about 14 feet above the water. This is probably the seven foot seam recorded by Dr. Selwyn, as being near the International boundary. As the banks lower very much in that direction and the seam maintains its position above the water the rocks of the upper part of the exposure run out. Another mine is opened on this seam a quarter of a mile east of the one noted above.

Section on the south-east quarter of Sec. 6, opposite a small branch from the south.

	Feet. in.	Feet.	
Surface of prairie		1859 above tide	Sec. 6, Tp. 1, R. 6.
Yellow clay and sand	22 00		
Ironstone	1 00		
Clay	7 00		
Lignite	4 06		
Clay	0 10		
Lignite	0 01		
Clay	0 07		
Lignite	0 08		
Concealed to water of stream	12 00		
Elevation of stream about		1810	
	48 08		

Dr. Selwyn's note* on another exposure to the east of this is: 'To the south, a few yards north of where the International boundary crosses the east branch of Short creek, a seam is exposed in the bank seven feet thick, with a shaly parting of three inches, at about two feet from the top. It is not more than fifteen feet beneath the surface of the plain, and the drift covering is thin. Eight or ten feet below the seam is the water level of the creek.

It can hardly be supposed that these seams are other than the ones exposed at a lower level in the main valley of Short creek. This would indicate a dip of the beds to the west which is also noted in the sections nearer the mouth in Sec. 24, with the exception, that in the north the sandstones separating the lower beds of coal from the one at Sutherland's tunnel thin out very much.

Evidence of this in the sections at the south can only be obtained by boring.

Souris river from Estevan southward.

The branch which here runs northward through the townships to the large valley passing to the south of Estevan is much newer in point of age than that which comes from the west in the larger valley. The amount of erosion which the southern branch has been able to accomplish is much less, but the channel it has worn down is deep and narrow. Cut banks are numerous but the superficial covering of drift is found to be much thicker away from the large valley on either hand, so that the sections as noted in many cases above, are obscured by the sliding down over their face of the finer grained material found in the drift. New valley.

* Report of Progress Geol. Surv. Can. 1879-80 p. 6A.

Grade of stream.

The grade of the bed of the stream on this branch being in a new channel is much steeper than in the old valley. From the International boundary the fall is in the vicinity of one hundred feet. The grade is very uniform but steeper in the central portion or from Secs. 15 to 28. The sections as given above show that the stream has cut through and exposed all the seams that are seen in the vicinity of Estevan. The plotting of the sections also show that there is a perceptible rise in the beds toward the south.

Lower horizon.

The lower horizon as exposed at Carrols on Sec. 14 is shown in Dr. Dawson's section (Paragraph 210) to consist of three seams, the upper one divided into two by a dark carbonaceous shale. The character of the lowest member is given in the following analysis*.

'*Souris Valley......Layer 19.* A weathered specimen separating into laminae horizontally. Clay from overlying bed filling fissures. Ash yellow-brown.

Water..	13 94	By rapid coking
Fixed carbon....................................	45 27	38·35
Volatile combustible matter....................	35 00	
Ash..	5 79	
	100 00	

These seams are also exposed in several places to the southern par' of Sec. 28 where coal seams are found in the bed of the stream at a series of rapids.

Middle horizon.

The middle horizon or the one supposed to be represented by the seam mined out in the hill south of the Dominion mine, is represented in Dr. Dawson's section by an upper seam of six feet six inches. This is probably good enough in quality for local use. The specimens analysed being weathered, the result is not promising.

'*401 Souris Valley......Layer 2.* A weathered specimen, soft and crumbling. Ash, grayish-white.

Water..	17 97	By rapid coking
Fixed carbon....................................	32 86	30·10
Volatile combustible matter....................	44 56	
Ash..	4 61	
	100 00	

This middle seam was opened near Sec. 9 by one of the settlers and the coal is said to be of fair quality. Burnt shales indicating

* Report on the Geology and Resources of the region in the vicinity of the Forty ninth Parallel, by G. M. Dawson, Montreal. 1875, p. 170.

its presence along the sides of the valley were seen at slightly higher elevations in going up the valley. On Sec. 33 the level of the burned shales is at about 1825 feet. No exposures of this seam are to be seen up to the southern part of Sec. 22, where it is given in the section quoted as having a thickness of 7 feet and 3 inches (Sec. 216) The analysis by Dr. Dawson shows it to be of good quality ; better than the specimen from near the mouth of the river.*

'403 *Souris Valley. ....7 foot seam.* Hard compact black lignite, breaking with pseudo-conchoidal fracture, and showing traces of structure of wood. Ash, yellowish-white, light.

Water	15 11	By rapid coking
Fixed carbon	47 57	41·67
Volatile combustible matter	32 76	
Ash	4 56	
	100 00	

On Sec. 14, Tp. 1, R. 8, it was opened by the Boundary Commission for use in the smithy. The analysis given by Dr. Dawson is as follows :†

'402 *Souris Valley.* Black compact lignite with much woody structure apparent. Ash yellow.

Water	14 73	By rapid coking
Fixed carbon	42 48	34·07
Volatile combustible matter	39 99	
Ash	2 80	
	100 00	

The fall in the river here would indicate that if the seam did not rise much to the south it would probably cross the stream in Sec. 15 or perhaps a little further south. The grade of the river above this becomes much flatter indicating probably a more compact bed forming the floor for a short distance and the cut banks above this are covered by slidden clay from the surface. A good exposure was sought for in the almost circular bend in the bottom of which is situated the Mounted Police outpost Wood End. The banks surrounding this are all scarped but show only clay. The seam should be found near the water.

The upper horizon, represented at Estevan by the four foot seam and the Dominion seam, is not represented in the sections in the lower part of the narrow valley but makes its appearance in Sec. 33 just below Upper horizon.

* See Boundary report as before, p. 171.

† Idem p. 170.

the boulder clay. Two miles farther south-east a burned seam on Sec. 27 is probably of this horizon and is seen again on Sec. 22. No good exposure of this is to be made out in Sec. 23, but Dr. Dawson found four feet of coal at about fifteen feet below the prairie level. (see paragraph quoted, 217 p. 45 F).

Details of sections.

Section at coal mine, south-east quarter of Sec. 11 Tp. 2 R. 8.

	Feet	in.		Elevation. Feet.
Yellow sandstone	28	0	Top of hill behind mine	1836
Yellow clay		6	Top of exposure	1819
Light gray clay	5	0		
Lignite		6		
Light gray clay	3	6		
Lignite	6	0		
Reported below			Bottom of coal in tunnel	1776
Clay	1	0		
Lignite	5	0	Level of water in slough	1756

Sec. 11, Tp. 2, R. 8.

One of the men who opened this seam and the tunnel to test the coal, Mr. Rook of Estevan, informs me that below the six foot seam they found a clay parting of 12 inches and a five foot seam of very good lignite beneath. The coal that was taken out of this tunnel is admitted by several in the town to have been the best in quality of any mined in the district near Estevan.

Near the western edge of Sec. 11, the clays and sands exposed on the eastern part of the same section above the coal are again seen, but the upper part of the series is somewhat different. The exposure does not show the coal although it is probably present beneath the grassy slope.

	Feet	in.	Elevation. Feet	in.
Top of exposure			1806	6
Gray clayey sandstone	25	0		
Ironstone band		2		
Gray clay	1	0		
Brown clay	1	0		
Lignite		4		
Gray clay, brown at top	3	0		
Bottom of exposure			1776	

A little farther to the west where the stream enters the larger valley, on the point and just inside the bend on Sec. 10, the lower coal seams are partly exposed. The surface is decomposed and the thickness of

the seams is not well brought out. There appear to be two or three of them, but all rather thin. At about 70 feet above the river. a red band shows where a seam has been burned out. This may be the middle seam of the section across the river. It would be here at about 1820 feet above sea. A few feet of hardened sandstone show at about 1836 feet. Sec. 10, Tp. 2 R. 8.

This burnt seam is not shown in the section at the mine, a mile to the east and is probably above the beds there exposed. The yellow sandstone there seen is not represented in this section, nor is it seen near Estevan and is probably not a persistent member.

The sections given by Dr. Dawson, though not very exact as to location are carefully measured and that given on p. 89 of the report on the Geology and Resources of the 49th Parallel, is perhaps taken at the bend in Sec. 10, where we noted a similar arrangement of the beds.

The paragraph referring to this locality is as below:

"209. Six miles north from Wood End Depot, on the bend of the river, the following section occurs:—

	Feet.	in.
1 Fallen bank, no section, (about)	8	0
2 Finely stratified grayish sandy clay	7	0
3 *Lignite*	0	7
4 Sandy clay, grayish, laminated, including two leaf beds each a few inches thick	7	7
5 Yellowish fine sandy clay passing below to gray soft sandstone.	11	5
6 Ironstone, a nodular layer	0	3
7 Gray clay	1	0
8 Whitish clay	1	0
9 Carbonaceous shale	3	3
10 Gray clay	3	6
11 Ironstone	0	2
	43	9

The beds appear to be perfectly horizontal. Those of sand and arenaceous clay, though having the appearance of well characterized layers at a little distance, and giving the banks a ribboned aspect are found, on closer examination, to pass almost imperceptibly into each other. This peculiarity is often to be observed in almost all localities where these rocks are found. The so-called leaf beds are of a grayish purple tint, and contain many impressions of flag-like, parallel-veined leaves, which, though distinct enough when freshly taken from the bank, are impossible to preserve on account of the crumbling nature of the matrix. The ironstone, though generally forming extensive sheets, is nodular in structure, and varies a good deal in thickness. It

weathers a bright brownish red, is hard, compact, and very heavy, and on fresh fractures is bluish to yellowish gray.

'210. A short distance south of this locality, the bank shows the following section very perfectly :—

		Feet	in.
	Prairie sod.		
1	Mixed shale and drift	7	0
2	*Lignite*	6	6
3	Grayish sandy shale (about)	4	0
4	*Lignite*	1	6
5	Grayish and yellowish well-stratified fine sandy and shaly clays	14	0
6	Ironstone (nodular)	0	4
7	Grayish and whitish clays	2	0
8	Carbonaceous shale	1	0
9	Gray soft sandstone	1	8
10	*Lignite*	1	0
11	Gray and yellow laminated sandy clays	5	0
12	Ironstone (nodular)	0	3
13	*Lignite*	1	7
14	Carbonaceous shale	1	6
15	*Lignite*	2	2
16	Gray sandy clay	2	0
17	*Lignite*	1	5
18	Sandy underclay with large and small roots badly preserved	1	6
19	*Lignite*	3	2
20	Grayish sandy clay		
		57	7

The lower lignite beds are of excellent quality, firm and compact, and in some places show spots of fossil resin. The structure of the component wood is also in many instances very plainly apparent. The upperlignite, lying immediately below the surface, is soft and decomposed where exposed, being in many places penetrated by roots from above. It might however, prove equaliy compact with the lower beds where undisturbed. Layer 18, is one of the few instances in which lignite was observed to lie upon an evident underclay with roots. The ironstones are specially good and compact in this section. Owing to the wearing away of the softer strata, a large quantity of this material strews the surface of the hillside.'

Of the sections quoted above, the first appears to bear great resemblance to that given as exposed on the western part of Sec. 11, with the exception that the measures between the two ironstone bands are there somewhat thinner. The section above, which appears to have been in the narrow valley is evidently continued to a lower level and so shows the coal seams which are covered on the more easy slope of

the wide river flat. The upper coal seam of the section, 6 feet 6 inches in thickness, is probably now burned along the outcrop and appears again at an improvised lime kiln where the elevation of the burnt seam is at 1820 feet. This is no doubt higher than that of the seam in Dr. Dawson's section and would show a slight rise to the south. This is about equal to the rise of the bed of the stream for a short distance.

On the north part of Sec. 33, the eastern bank shows a small outcrop near the top and again near the stream. Sec. 33, Tp. 1, R. 8.

	Ft. above tide.
Surface of prairie	1880
Boulder clay 5 feet on part of a seam of lignite (3 in. showing)	1875
Covered to	1830
Sandstone red burned 5 feet	
Probable burnt seam	1825
Covered to	1785
Clay ironstone band	1785
Several thin coal seams as on Sec. 10	
Level of stream	1775

The section given by Dr. Dawson in paragraph 212 of the report cited is probably near this and is as follows.

'212. Nearly three miles southward from the last mentioned locality, in following up the valley, another very good section occurs on the east side of the stream, where in one of its many devious windings, it has undermined the bank. This section is specially interesting, as affording one of the best localities for the collection of shells of Mollusca characteristic of the formation. The section is as below, measurements being estimated :—

	Feet.	in.
Sand and sandy clay, stratified and yellowish in general colour	40	0
Lenticular mass of poor clay ironstone running out rapidly in both directions	2	6
Gray sand	2	0
Shell bed	1	6
Lignite	2	0
Sand and clay	10	0
	58	6

'213. The shell bed is of hard gray sandy clay and in some places is very full of shells, which are also less crushed and in better state of preservation than is usual in this formation. The most common Mollusk is *Melania Nebrascensis*, M. & H. which occurs in all stages of growth and several varietal forms. There is also a second species of this genus or of *Goniobasis*; fragment of *Unio* and *Paludina* and a few examples of

NOTE.—*Melania* Nebrasceusis is now called *Goniobasis Nebrasccusis.*

Corbula (*Potamomya*), *mactriformis* M. & H. The latter must be considered a brackish water type, but with this exception, no brackish or salt water forms are found in these sections of the Souris valley. The Mollusca exactly resemble those of the Fort Union or Great Lignite Group of the Missouri, and fix with certainty the stratigraphical position of the beds here represented.'

Secs. 33 and 27 From the bend in Sec. 33, southward, the top seam is seen to be burned along the edge of the bank. On the west bank at the bend the section is greatly concealed by sliding clay—the face showing gray clay but near the base the dark clay and ironstone is very like that in the lower part of the sections near Estevan. At the south-west corner of Sec. 27 the top of the bank is at 1890 feet. A burned seam is seen at 1865 and in the river bed at 1800 two feet of one of the lower seams show in the water.

Sec. 22. On Sec. 22, near the centre, a cut-bank on the east side, shows the following—

	Ft. above tide.
Top of bank	1890
Band with a little lignite (prob. burnt seam of Sec. 27)	1870
Top of yellow sands and sandstone	1855
Bottom of sandstone	1845
Traces of lignite below	

On the south-east corner of this Sec. is the exposure on the west side of the stream that is recorded by Dr Dawson in paragraph 215. As I could not cross the stream his section is given below with the probable elevations added so as to compare with my sections :

'215. South of the last section and about one mile nearly due north of the position occupied by Wood End Depot, an exposure, showing the most valuable lignite bed I have seen in the Souris valley, is situated. The beds are arranged thus :—

	Ft. in.	Est. elev.
1 Drift material (about)	8 00	1890
2 Yellowish and gray stratified sandy clays, obscured in most places by slips of the bank	52 00	1838
3 *Lignite*	7 03	1831
4 Gray soft arenaceous clay	1 00	or more

'216. The bottom of the lignite is about twenty-five feet above the level of the river below, and this part of the section, though apparently consisting of yellowish sandy clays like those overlying it, is obscure. The lignite is continuously visible for at least two hundred feet along the face of the bank, and seems to preserve uniformity of character and thickness.

'Externally it is often crumbling, and mixed with clay which has penetrated its joints from above; but where freshly exposed; it is hard and compact. It is quite black on freshly fractured surfaces, but has a brown streak, and in many places the structure of the original wood is quite discernable. Some surfaces are strewn with fragments of mineral charcoal like that found in many true coals. Other specimens are apparently structureless, and resemble cannel-coal in appearance though not in composition. The upper beds of arenaceous clay yield a few poorly preserved shells (*Paludina, &c.*)

'217. On the opposite side of the river valley, near this place, the upper part of the bank shows a good section of arenaceous clay, below which, and some fifteen or twenty feet below the prairie level is a seam of lignite of good quality, four feet in thickness. This lignite bed would seem to occupy a position stratigraphically superior to the last." Sec. 23, Tp. 1, R. 8.

This section in the above paragraph (217) is probably on the south west corner of Sec. 23. The bank is well cut showing about forty-five feet of clays and dark yellow sands near the top. There are two lignite exposures in the bank, but we could not dig out a good section owing to the fact that a great deal of it had been burnt. There is a broad patch of red burnt clay at thirty-five feet above the stream. This must be about the horizon of the seam observed by Dr. Dawson across the river. At 1880 feet or about 10 or 12 feet below the prairie level there is another lignite streak but at the only point at which I could reach it most of the coal had been burned. This is no doubt the four feet seam of the paragraph above.

On Sec. 14 on the east bank near the centre of the Sec. the lower lignite again outcrops about 15 feet above the stream. While the Boundary Commission had a depot near this place coal was taken from this seam for the smithy, but Dr. Dawson observes that it did not give a sufficiently intense heat for welding. Sec. 14.

The sandstones above the lower coal seam outcrop again on Sec. 15 but the banks above this are not so high and are generally grass.grown. In Sec. 4 there is a cut-bank 40 feet high, but it shows mostly drift material. In Sec. 6 the banks are only thirty feet high and show only sands and clays slidden from the surface. Secs. 15 & 4.

GEOLOGICAL SURVEY OF CANADA
ROBERT BELL, M.D., Sc.D., LL.D., F.R.S., ACTING DIRECTOR.

SECTION OF MINES

ANNUAL REPORT

FOR

1902

ELFRIC DREW INGALL, M.E.

Associate of the Royal School of Mines, England, Mining Engineer to the Geological Survey of Canada.

ASSISTANT

J. McLEISH, B.A.

OTTAWA
PRINTED BY S. E. DAWSON, PRINTER TO THE KING'S
MOST EXCELLENT MAJESTY
1903

15—s

No. 835

To the Director,
Geological Survey of Canada.

SIR,—Herewith I beg to hand you the detailed annual report of the Section on the mineral industries of Canada for 1902. The preliminary summary statement for that year, which was completed on Febuary 27, is of course replaced by the revised statement herein contained.

The work of the Section, as in the past, has consisted not only in the preparation of the annual report, but in the collection, recording, &c., of technical information, and in making investigations into a great variety of matters pertaining to the economic mineral resources and the mineral industries of the country, as well as in answering the numerous enquiries on these subjects constantly coming to hand.

Thanks are due to those who, although too numerous to mention individually, by answering our circulars or letters, provided much valuable material. Our acknowledgments are also due to the provincial mining bureaus of Nova Scotia, Quebec, Ontario and British Columbia, as well as to the Dominion Customs and Inland Revenue departments for aid received. Appreciative acknowledgment is made of the important aid in the whole work of the Section rendered by Mr. J. McLeish and Mrs. W. Sparks. Thanks are also due to Mr. Theo. Denis, B.Sc., who, at my request, has compiled from the available facts the special articles on coal, salt and tripolite embodied in the report.

I am, sir,
Your obedient servant,

ELFRIC DREW INGALL,
Mining Engineer to the Geological Survey.

Section of Mines,
October 31st, 1903.

EXPLANATORY NOTES.

YEAR AND TON USED.

The year referred to throughout this report is the calendar year, except for the figures of imports, which refer to the fiscal year ending June 30. The ton is that of 2,000 pounds, unless otherwise stated.

EXPORTS AND IMPORTS.

The figures given throughout the report referring to exports and imports are compiled from data obtained from the books of the Customs Department, and will occasionally show discrepancies, which, however, there are no means of correcting.

The exports and imports under the heading of each province do not necessarily represent the production and consumption of the province; e.g., material produced in Ontario is often shipped from Montreal and entered there for export, so falling under the heading, Quebec.

NOTE.—N.E.S. = Not elsewhere specified.

VALUES ADOPTED.

The values of the metallic minerals produced, as per returns to this Department, are calculated on the basis of their metallic contents at the average market price of the metal for the current year. Spot values have been adopted for the figures of production of the non-metallic minerals.

GENERAL NOTES.

As in the past, care is taken to avoid interference with private interests in the manner of publishing results, and all returns of production of individual mines are treated as confidential, unless otherwise arranged with those interested. The confidence of the mining community, thus gained, has resulted in an increasingly general response to our circulars, although to complete our data, personal application is still necessary in a small number of instances, and a yet more prompt

MINERAL PRODUCTION OF CANADA.

course the inflation due to the discovery and exploration of the Yukon placers necessarily diminishes rapidly as the richer portions get worked out and the growth in the output from more systematic mining of the poorer gravels, will in the nature of things be slow. The Yukon was credited with an output of $14,500,000 for 1902 whilst for the previous year it produced $18,000,000, a difference of $3,500,000.

In the following table it will be noticed that there have been heavy decreases in values in all the metallic products except pig iron from both home and foreign ores and in nickel. In copper this was due to the fall in the price of the metal more than counteracting a small increase in the amount. In the other metals the decline is registered also against the output and enhanced by lower values. By reference to the folded table it will be seen that the decrease in the grand total of the metallic products is $6,147,175. Against this we have an increase in the non-metallic products of $3,673,814, leaving still a shortage of $2,473,361. Referring again to the following table, it will be seen that the principal contributors to the increase in the non-metallic class have been the coal, coke and cement industries which account for nearly $3,000,000.

PRODUCTS.	QUANTITY.		VALUE.	
	Increase.	Decrease.	Increase.	Decrease.
	p. c.	p. c.	p. c.	p. c.
Metallic—				
Copper	2·58			26·00
Gold		11·57		11·57
Pig iron (from Canadian ore only)		13·76		13·95
Pig iron (from both home and imported ores)	30·44		20·80	
Lead		55·77		58·47
Nickel	16·37		9·39	
Silver		22·53		31·45
Non-metallic—				
Asbestus and asbestic	·49			8·85
Coal	15·51		20·59	
Coke	37·35		23·69	
Cement	60·42		70·83	
Gypsum	13·02		5·62	
Natural gas				42·27
Petroleum		14·74		5·61

The relative value to the country of the various mineral industries will be made plain by a study of the table given below. Coal and coke, together with gold, stand out prominently as the twc main

mineral assets of the country, accounting for over 58 per cent of the income yielded by its mines. The whole class of metallic products is to be credited with about 56 per cent and the non-metallic and structural class with about 44 per cent, the latter contributing about 12 per cent of the grand total. MINERAL PRODUCTION OF CANADA.

PROPORTIONATE VALUE OF DIFFERENT MINERAL PRODUCTS, 1902.

Products.	Contributing over 10 p. c.	Contributing between 10 and 1 p. c.	Contributing under 1 p. c.	Total.
1. Gold	33·41			
2. Coal and coke	25·05			
3. Nickel	....	7·87		
4. Copper	....	7·06		
5. Bricks (estimated)	....	4·06		
6. Silver	....	3·51		
7. Building stone (estimated)	....	2·98		
8. Asbestus	....	1·80		
9. Cement	....	1·77		
10. Pig iron (from Canadian ore)	....	1·63		
11. Petroleum	....	1·48		
12. Lead	....	1·46		
13. Lime (estimated)	....	1·39		
14. Iron ore (difference between production in Canada and quantity used in making pig iron)	....	1·09		
15. Gypsum	....	....	·56	
16. Sewer pipe	....	....	·47	
17. Salt	....	....	·46	
18. Terra cotta	....	....	·43	
19. Sundry under 1 per cent	....	....	3·52	
Total	58·46	36·10	5·44	100·00

The relative value of the production of the different provinces is given by the figures tabulated below. In respect of Nova Scotia they will be found to differ from those given in the *Canadian Mining Review*. This is due to the different points of view adopted. In the former figures are included items which could not properly find a place in a government report, such as this, which purports to illustrate the products of Canadian mines. The *Mining Manual* figures include both pig iron and steel made from all ores both Canadian and imported. Following the consistent practice of the past in this report, only those values are included in the grand total which represent products of Canadian minerals. The full data illustrative of the allied metallurgical industries, inclusive of the results of smelting foreign ores, are given, however, in the article on iron farther on in the report.

MINERAL PRODUCTION OF CANADA.

PRODUCTION BY PROVINCES, 1902.

Province.	Value of Production.	Per cent.
Nova Scotia	$ 11,586,479	18·1
New Brunswick	607,129	·9
Quebec	3,743,636	5·9
Ontario	14,486,765	22·7
Manitoba and North-west Territories including Yukon.	16,107,198	25·2
British Columbia	17,334,590	27·2
Total	63,865,797	100·0

In view of the discussions which have taken place at the sessions of the Canadian Mining Institute as to what was the correct way of illustrating the value of Canada's mineral products, it may be as well to mention the standpoint adopted by the Mines Section in its treatment of the subject.

Firstly : it is chiefly essential to correctly ascertain the quantities produced, eliminating all possible errors and checking where possible by railway shipments etc., etc. As, however, the quantities of such very diverse substances cannot be added together, it is manifestly necessary *for the purpose of making up the grand total* to adopt some basis of valuation which shall be definite enough to be easily intelligible and shall be comparable from year to year, so as to rightly illustrate growth. For the metallic ores, whose only uses are as sources of a metal or metals and which are of most varying constitution, the final value of the amounts of these metals contained in the ores is manifestly the only common denominator or standard to which they can be brought. This is the method adopted by the United States Government and in part by that standard publication the *Mineral Industry* issued annually by the Engineering and Mining Journal of New York.

Whilst other reliable authorities may properly adopt other methods equally correct and legitimate, with a view to illustrate the mineral industries from other standpoints, it is believed that this method best meets the needs of this report. It must be borne in mind also that this applies only to the general tabulation of the total mineral production of the country, and that in the Section's full annual report the details relating to the different industries are given in the body of the publication.

For the non-metallic minerals it is manifest that only spot values can be adopted. They are practically all used as such and their value

is a very variable quantity, often made up, as far as the consumer is concerned, mostly of cost of carriage to the point of consumption. Thus the same material would have widely varying values at different points. The only remaining possible basis is evidently to value the material at its point of departure from the producer. This is found still to be only a rough approximation to uniformity and each separate material has to be considered by itself. Where there is some point of shipment or distribution common to a district, a more definite and uniform basis can be arrived at, as with the phosphate of the province of Quebec which was all handled at Montreal and where the price was always quoted f.o.b. at that port.

MINERAL PRODUCTION OF CANADA.

It must also be borne in mind that no presentment of data, statistical or otherwise, will meet the very changeful needs of all the people likely to be interested in the subject. The consumer is concerned chiefly with the price he has to pay for the article, the producer in the value he can realize on his products.

The main thing is to have the fundamental data orrect and to adopt a standard so definite and clear that any one can make the allowances necessary for the illustration of the industry from his particular standpoint.

EXPORTS.

MINERALS AND MINERAL PRODUCTS OF CANADA DURING CALENDAR YEAR 1902.

Exports.

Products.	Value.	Products.	Value.
Antimony ore	$ 13,658	Manufactures of metals	
Arsenic	16,192	other than iron or steel	$ 347,766
Asbestus	995,071	Mica	391,812
Barytes	700	Mineral pigments	6,182
Bricks	12,786	Mineral waters	2,787
Cement	2,267	Nickel	1,007,211
Chromite	7,535	Oil crude	40
Clay, manufactures of	374	Oil refined	146
Coal	5,402,225	Ores unspecified	78,854
Coke	180,920	Platinum	116
Copper	2,476,516	Phosphate	1,880
Felspar	13,708	Plumbago crude	23,097
Gold	16,921,861	" manufactures of	1,742
Grindstones	13,266	Pyrites	50,178
" rough	11,223	Salt	3,798
Gypsum crude	295,215	Sand and gravel	119,120
" ground	5,101	Silver	1,820,058
Iron and steel	2,460,781	Stone unwrought	124,829
Iron ore	1,065,019	" wrought	8,632
Lead	457,162	Other articles	282,735
Lime	116,009		
Manganese ore	4,062	Total	$34,742,634

MINERAL PRODUCTION OF CANADA.

Of the value of the minerals exported by Canada, as shown in the above table, over one-half is represented by gold. This with the other metallic products—copper, nickel, silver, iron and steel—together with coal, coke and asbestus, aggregate about 98 per cent of the whole. From the following table it will be seen that the United States takes nearly 95 per cent of the exported mineral products, the other countries taking only comparatively insignificant amounts.

Exports.

EXPORTS.

DESTINATION OF PRODUCTS OF THE MINE, DURING THE FISCAL YEAR 1901-1902.

Destination.	Value.	Destination.	Value.
United States....	$33,145,856	British West Indies......	25,301
Great Britain............	802,842	St. Pierre	21,528
Belgium	325,191	Cuba...........	10,235
Newfoundland...........	288,815	China.......	6,545
Germany................	105,671	Russia..................	2,310
British Africa......	51,842	Hong Kong	930
British Guiana..	37,379	Australia...	520
France...	35,382	Spain.........	450
Italy.....................	30,896	Mexico.........	125
Denmark	28,372	Total............	$ 34,947,574
Norway and Sweden......	27,384		

The following table illustrates in a rough way the needs of this community in regard to mineral substances and their products which might possibly be met to a greater or less extent in the future with the further discovery and development of our own resources. The most prominent items are coal (whose imports amount in value to over one-fifth of the total) and manufactures of machinery, accounting for over one-third of the whole, or together amounting to about 57 per cent. The items going to make up the latter will be found in their appropriate connection later in the report. Their bearing is rather on the manufacturing than in connection with the mineral industries. In regard to the coal item, 54 per cent represents imports of anthracite of a quality of which we have as yet none mined in this country.

MINERAL PRODUCTION OF CANADA.

Imports.

IMPORTS.

MINERALS AND MINERAL PRODUCTS, FOR FISCAL YEAR 1901-1902.

Products.	Value.	Products.	Value.
Alum and aluminous cake	$ 54,092	Litharge	$ 47,021
Aluminium	30,496	Lithographic stone	12,272
Antimony	16,821	Manganese, oxide of	5,360
" salts	22,455	Marble, and mfrs. of	130,424
Arsenic	6,004	Mercury	56,615
Asbestus and mfrs. of	52,464	Metallic alloys—	
Asphaltum	102,317	Brass, and mfrs. of	1,014,329
Bells and gongs	85,556	Britannia metal	9,879
Bismuth	814	German silver	13,938
Blast furnace slag	1,606	Metals, N.E.S., and mfrs. of	906,617
Borax	73,725	Mineral and bituminous substances, N.E.S.	64,572
Bricks and tiles	172,281	Mineralogical specimens	1,094
" fire	329,116	Mineral and metallic pigments, paints and colours	1,021,259
Buhrstones	2,559	Mineral waters	91,871
Cement	863,646	Nickel	1,539
Chalk	11,337	Nitrate of soda, &c	133,663
Clays	140,521	Ores of metals, N.E.S.	727,099
Coal	12,998,547	Paraffine wax	12,750
" tar and pitch	98,551	" candles	5,752
Coke	842,815	Petroleum, and products of	1,107,207
Copper and mfrs. of	1,507,354	Phosphate (fertilizer)	15,370
Copperas	4,337	Phosphorus	520
Cryolite	8,842	Platinum	19,357
Crucibles, clay or plumbago	28,635	Precious stones	848,731
Earthenware	1,275,093	Pumice	7,254
Emery	38,368	Salt	425,234
Felspar, quartz, flint, &c	16,256	Saltpetre	61,559
Fertilizers	98,782	Sand and gravel	58,668
Fuller's earth	3,909	Slate, and mfrs. of	72,601
Gold and silver, and mfrs. of	351,460	Stone and mfrs. of	213,540
Graphite, and mfrs. of	39,137	Sulphate of copper	67,710
Gypsum, plaster of Paris, &c	4,587	Sulphur	325,307
Iron and steel—		Sulphuric acid	4,626
Pigs, scraps, blooms, &c.	1,565,213	Tin, and manufactures of	2,293,958
Rolled—bars, plates, &c., including chrome steel	7,768,332	Whiting	42,136
Ferro-silicon, ferro-manganese, &c	150,977	Zinc, and manufactures of	233,467
Manufactures of, machinery, hardware, &c	22,294,501		
Lead, and mfrs. of	273,953	Total	61,406,342
Lime	17,584		

ABRASIVE MATERIALS.

ABRASIVE MATERIALS.

Grindstones.

The production of grindstones, &c. in 1902 was 4,633 tons, valued at $44,118, or an average of $9.52 per ton. The output has varied but little from year to year for the past fifteen years and is apparently restricted to supplying a limited local demand in the eastern and maritime provinces and in the New England States.

These abrasives, grindstones, wood pulp stones, scythe-stones, &c., have for many years been made in the eastern provinces of Canada, from the millstone grit of the Carboniferous formation, which occupies a large portion of the surface of the eastern half of the province of New Brunswick and the northern and north-western parts of Nova Scotia.

The grindstones are nearly all shipped in a finished condition and are worth about $10 a ton. At many of the quarries there is a considerable production of foundation and building stone, besides rough stone for breakwater and harbour works.

Statistics of the production by provinces since 1886 are given in Table 1 below.

Production.

TABLE I.

ABRASIVE MATERIALS.

ANNUAL PRODUCTION OF GRINDSTONES.

CALENDAR YEAR.	NOVA SCOTIA.		NEW BRUNSWICK.		TOTAL.		AVERAGE VALUE PER TON.
	Tons.	Value.	Tons.	Value.	Tons.	Value.	
1886	1,765	$24,050	2,255	$22,495	4,020	$46,545	$11 58
1887	1,710	25,020	3,582	38,988	5,292	64,008	12 10
1888	1,971	20,400	3,793	30,729	5,764	51,129	8 87
1889	712	7,128	2,692	23,735	3,404	30,863	9 07
1890	850	8,536	4,034	33,804	4,884	42,340	8 67
1891	1,980	19,800	2,499	22,787	4,479	42,587	9 51
1892	2,462	27,610	2,821	23,577	5,283	51,187	9 69
1893	2,112	21,000	2,488	17,379	4,600	38,379	8 34
1894	2,128	16,000	1,629	16,717	3,757	32,717	8 71
1895	1,400	14,000	2,075	17,932	3,475	31,932	9 19
1896	1,450	14,500	2,263	18,810	3,713	33,310	8 97
1897	1,407	17,500	3,165	24,840	4,572	42,340	9 26
1898	1,422	12,350	3,513	32,425	4,935	44,775	9 07
1899	1,378	10,300	3,133	32,965	4,511	43,265	9 59
1900	1,411	12,600	4,128	40,850	5,539	53,450	9 65
1901	358	3,200	4,223	42,490	4,581	45,690	9 97
1902	1,074	8,118	3,559	36,000	4,633	44,118	9 52

ABRASIVE MATERIALS.

Grindstones.

The localities where operations are being carried on have been known and worked for many years. The principal quarries are situated in the Province of New Brunswick, on the Bay of Chaleur at Clifton and Stonehaven; on Miramichi Bay in the vicinity of Newcastle, and along the shore of Shepody Bay in the Bay of Fundy; while in Nova Scotia the points to which attention has been chiefly directed, are at Lower Cove, Cumberland Basin, and at Woodbourne, Pictou county. A large proportion of the production is exported, chiefly to the United States. Statistics of exports and imports are given in Tables 2 and 3. Almost $25,000 worth of grindstones, &c., were imported in 1902, principally into the provinces of Ontario and Quebec.

TABLE 2.

ABRASIVE MATERIALS.

EXPORTS OF GRINDSTONES.

Exports.

Calendar Year.	Value.
1884	$28,186
1885	22,606
1886	24,185
1887	28,769
1888	28,176
1889	29,982
1890	18,564
1891	28,433
1892	23,567
1893	21,672
1894	12,579
1895	16,723
1896	19,139
1897	18,807
1898*	25,588
1899*	23,288
1900*	42,128
1901*	29,130
1902*	24,489

* Including stone for the manufacture of grindstones.

Abrasive Materials.

Grindstones.

Imports.

TABLE 3.

ABRASIVE MATERIALS.

IMPORTS OF GRINDSTONES.

Fiscal Year.	Duty.	Tons.	Value.
1880	....	1,044	$11,714
1881	....	1,359	16,895
1882	....	2,098	30,654
1883	....	2,108	31,456
1884	....	2,074	30,471
1885	....	1,148	16,065
1886	....	964	12,803
1887	....	1,309	14,815
1888	....	1,721	18,263
1889	....	2,116	25.564
1890	....	1,567	20,569
1891	....	1,381	16,991
1892	....	1,484	19,761
1893	....	1,682	20,987
1894	....	1,918	24,426
1895	....	1,770	22,834
1896	....	1,862	26,561
1897	....	1,521	25,547
1898	....	....	22,217
1899	....	....	27,476
1900	....	....	34,382
1901	....	....	39,068
1902 Grindstones not mounted and not less than 36 inches in diameter.....	15 p.c.	....	34,496
1902 Grindstones N.E.S......	25 p.c.	....	6,342
			40,838

Practically the same operators have been engaged in quarrying as in previous years. The list is as follows:—

Nova Scotia.

NOVA SCOTIA—

The Atlantic Grindstone Company, Lower Cove, Cumberland county.

J. W. Sutherland, Quarry Island, Woodbourne, Pictou county.

New Brunswick.

NEW BRUNSWICK—

Henry Tower, Lower Rockport, Westmoreland county.

H. C. Read, Sackville, Westmoreland county.

A. D. Richard, Dorchester, Westmoreland county.

W. B. Deacon, Shediac, Westmoreland county.

C. E. Fish, Newcastle, Northumberland county.

J. B. Read, Stonehaven, Gloucester county. ABRASIVE MATERIALS.

Messrs. Lombard and Company, Clifton, Gloucester county, and Boston, Mass. Grindstones.

R. W. Knowles, Clifton, Gloucester county. New Brunswick.

Corundum.—The discovery of corundum in Ontario was brought to public attention in 1896 and the active mining and milling of the ore has been carried on since 1900. The production has been as follows :— Corundum.

	Quantity.	Value.
1900	3 tons.	$ 300.
1901	444 "	53,115.
1902	768 "	84,465.

The above production is practically all the result of the operations of the Canada Corundum Company, at the Craig Mine in the township of Raglan, Renfrew county, where they have a large and well equipped mill, operated by both steam and water power. The production in detail of the Canada Corundum Company, for the past two years, has been as follows :

	1901.	1902.
Corundum-bearing rock, treated	4,134 tons.	7,996 tons.
Grain corundum, graded	868,590 lbs.	1,611,200 lbs.
Grain corundum sold in Canada	171,537 lbs.	211,887 lbs.
" exported to England	20,331 "	176,342 "
" " United States	576,402 "	784,947 "
" " Europe	5,320 "	362,554 "
Total sales	773,590	1,535,730

It will be seen from the above, that the rock treated so far has averaged about 10 per cent of corundum.

The price realized at the mine is about 5½ cents per pound.

The price of corundum in wholesale lots at New York, was in December 1902 as under.

North Carolina corundum	7 cents	to 10 cents	per pound.
Chester, Mass. "	4½	" 5	"
Barrys Bay, Ontario, corundum	7½	" 9½	"

These prices were practically subject to no variation throughout the year.

Other companies organized for the purpose of conducting operations in corundum in Ontario are :—

The Crown Corundum and Mica Company, Toronto.

ABRASIVE MATERIALS.

Corundum.

The Ontario Corundum Company, Ottawa.

The Ontario Corundum Company are engaged on development work in the township of Carlow, and are said to be erecting a mill and other buildings.

TABLE 4.

ABRASIVE MATERIALS.

IMPORTS OF BUHRSTONES.

Imports of Buhrstones.

Fiscal Year.	Value.	Fiscal Year.	Value.
1880	$12,049	1892	$ 1,464
1881	6,337	1893	3,552
1882	15,143	1894	3,029
1883	13,242	1895	2,172
1884	5,365	1896	2,049
1885	4,517	1897	1,827
1886	4,062	1898	1,813
1887	3,545	1899	1,759
1888	4,753	1900	1,546
1889	5,465	1901	5,762
1890	2,506	1902*	2,559
1891	2,089		

* Buhrstones in blocks, rough or unmanufactured, not bound up or prepared for binding into mill-stones. Duty free.

TABLE 5.

ABRASIVE MATERIALS.

IMPORTS OF EMERY.

Imports of Emery.

Fiscal Year.	Emery. *a.*	Mfrs. of Emery. *b.*
1885	$ 5,066	$ 4,920
1886	11,877	5,832
1887	12,023	4,598
1888	15,674	4,001
1889	13,565	3,948
1890	16,922	5,313
1891	16,179	6,665
1892	17,782	6,492
1893	17,762	5,606
1894	14,433	2,223
1895	14,569	7,775
1896	16,287	11,913
1897	16,318	11,231
1898	17,661	15,478
1899	21,454	22,343
1900	19,312	25,615
1901	16,311	22,190
1902	14,476	23,892

a Emery in bulk, crushed or ground. Duty free.

b Emery wheels and manufactures of emery. Duty 25 p.c.

ABRASIVE MATERIALS.

Imports of Pumice Stone.

TABLE 6.

ABRASIVE MATERIALS.

IMPORTS OF PUMICE STONE.

Fiscal year.	Value.
1885	$ 9,384
1886	2,777
1887	3,594
1888	2,890
1889	3,232
1890	3,003
1891	3,696
1892	3,282
1893	3,798
1894	4,160
1895	3,609
1896	3,721
1897	2,903
1898	3,829
1899	5,973
1900	5,604
1901	5,516
*1902	7,254

* Pumice and pumice stone, ground or unground. Duty free.

Infusorial earth.

Infusorial Earth.—The localities where this mineral occurs have been mentioned in previous reports of the Mines Section. The following very much more complete presentment of the subject has been prepared at my request by Mr. Theo. Denis, B.Sc. This material, known under the various names of tripolite, tripoli, diatomaceous earth, kieselguhr, etc., is a pulverulent silicious material, white when pure, but having often a brownish discolouration. It is derived from the silicious shells of diatoms. The material is rarely pure, but usually mixed with a certain proportion of carbonate of lime, and of magnesia, clay, etc., the silica contents varying between 75 and 90 per cent.

The Diatomaceae are an order of unicellular algae, one of the lowest and simplest forms of vegetable life. They have beautifully sculptured very minute silicious shells or skeletons, called frustules, which are favourite subjects of study with microscopists. Diatoms exist in all parts of the world in immense numbers at the bottom of the sea and of fresh water, and are also found attached to the submerged parts of aquatic plants etc., and among mosses and in other damp localities. There are many genera, and the number of known species exceeds 1,500. They vary greatly in the form and markings of the valves which are often exquisitely scupltured, forming beautiful objects under the microscope and testing

ABRASIVE MATERIALS.

Infusorial Earth.

its highest powers. In some species the lines are found to equal 125,000 to the inch. Extensive fossil deposits of the silicious remains of diatomaceae occur in various localities, as at Bilin in Bohemia, and in Virginia, Nevada and California. They are sometimes used as polishing powder. They are abundant in guano.

Diatomaceous earth is very porous, the specific gravity being 0.25 to 0.30, owing to the numerous interstitial spaces and air cavities between the spicules and shells and within the latter, giving lightness and great absorbent power.

The uses to which diatomaceous earth is put are very varied and are probably capable of greater extension. Formerly, it was widely used in the manufacture of dynamite as an absorbent of the nitro-glycerine, its porosity which allows of its absorbing liquids to the extent of four to five times its own weight, rendering it eminently adapted to tha purpose. But in this connection it has been wholly replaced by cheaper absorbents such as wood pulp, sawdust etc. At present its chief use is as a polishing material, the grains being sharp and cutting, but fine enough not to scratch metal surfaces; it is also used as a boiler covering, its porosity rendering it a good non-conductor of heat. It can be used in the manufacture of bricks when great lightness is required, but owing to the difficulty of manufacture, these bricks are costly and cannot on that account be used for ordinary purposes. Such bricks can be made of one quarter the weight of ordinary bricks. Diatomaceous earth is also used to some extent in the manufacture of certain soaps, and as filtering material, etc.

For the purpose of comparison a few analyses of infusorial earth from various countries are here tabulated.*

Composition.	Hanover.	Germany.	Scotland.	Auvergne, France.	Maryland, U.S.	Virginia, U.S.	New Brunswick, Canada.
Silica	86.4	68.01	92.0	87.2	81.53	75.85	80.487
Ferric Oxide	1.5	6.82	2.5	. . . . . .	3.33	2.92	.951
Alumina	1.6	7.13	. . . . . .	2.0	3.43	9.88	3.146
Lime	1.3	. . . . . .	. . . . . .	. . . . . .	2.61	0.29	.342
Magnesia	. . . . . .	. . . . . .	. . . . . .	. . . . . .	5.63	1.63†	.283
Water	6.9	8.45	. . . . . .	10.0	3.47	8.37	13.332
Other volatile and organic matter	2.3	8·17	5.5	. . . . . .	. . . . . .	. . . . . .	
	100.00	98.58	100.00	99.2	100.00	98 95	98.548

*From the Mineral Industry Vol. VII. †Including potash and soda.

ABRASIVE MATERIALS.

Infusorial Earth.

A series of experiments as to the applicability of Canadian diatomaceous earths to commercial uses, was conducted by Dr. Hoffmann in the laboratory ofthe Geological Survey of Canada and the results were published at the time in the reports of the Department**. As those publications may not in some cases be easy of access it is thought that a reproduction *in extenso* of these tests would not be out of place here.

" The sample, the results of the examination of which are here given, came from Pollet River lake, Mechanic Settlement, King's county, New Brunswick, and was collected by Dr. R. W. Ells. It occurs in considerable quantity in this lake, the deposit, it is stated, being about four feet deep and readily obtainable either by dredging or by draining the lake...

" In texture it resembled an earthy chalk ; it is very fine grained but harsh to the feel ; adheres to the tongue ; in colour is light greyish white. Heated in a closed tube, it assumes a dark-grey colour, due to the separation of carbon and gives off an abundance of a somewhat ammoniacal, light brownish-yellow coloured water, the material evidently containing nitrogenous organic matter. After ignition with free access of air, its colour is reddish-white ; if treated with hydrochloric acid previous to ignition, the colour is white or at most has a just perceptible reddish tinge.

" When digested, either before or after ignition, with a boiling solution of caustic potash or soda, the silica readily passes into solution leaving a small amount of insoluble residue, which after ignition, has a light reddish-brown colour. The insoluble residue readily subsides from the solution. This latter, if the material has been treated before ignition, has a brownish yellow colour ; if after ignition, and consequently when free from organic matter, the solution is colourless.

" This sample had been kept in the dry atmosphere of the laboratory for a lengthened period, and was regarded as perfectly air-dried. At 100° C., the oxygen of the air exercises a modifying influence upon this material, so that in order to ascertain the correct loss by water at this temperature, it is necessary that the operation should be conducted in an atmosphere of hydrogen or carbonic acid.

** Reports of Progress 1878-79 and 1879-80.

ABRASIVE MATERIALS.

Infusorial Earth.

"An analysis of the air-dried material gave the following results :—

Silica	80·487
Alumina	3·146
Ferric Oxide	0·951
Lime	0·342
Magnesia	0·283
Carbonic Acid	0·011
Phosphoric Acid	?
Potash and Soda	?
Water—combined and hygroscopic and organic matter	13·321
	98·541

1. Water and organic matter—	
(a). Loss on drying over sulphuric acid	6·535
(b). Loss (in addition to that of a) on drying at 100° C., in a current of pure and dry hydrogen	3·582
(c.) Loss (in addition to that of a and b) on ignition (and after correction for carbonic acid)	3·204
Total	13·321

"The air-dried material left, on treatment with a boiling solution of caustic potash, 7·994 per cent. insoluble residue of a light reddish-brown colour (after ignition).

"As regards the economic value of this infusorial earth, it may be said to constitute an excellent polishing material; and although no experiments have been made to determine its absorbent power, it may reasonably be expected to prove well adapted for the preparation of dynamite. Again, the extreme facility with which it is dissolved by caustic alkalies (potash or soda) would suggest its advantageous employment for the manufacture of what is commonly known as "water glass" or "soluble glass," a preparation which meets with many important applications in the arts, as for instance, as a cement for the manufacture of artificial stone; for the hardening and preserving of building stones; in fixing fresco colours by the process of stereochromy; as an addition to soap in the preparation of the so-called "silicated soaps," etc."

"It has been desirable to ascertain experimentally its suitableness for the manufacture of bricks in imitation of the so-called "light or swimming bricks." These latter, owing to the porous nature of the silica composing the material from which they are made, combine great lightness with infusibility, and are remarkably bad conductors of heat on which account they constitute for many purposes of construction a valuable building material.

"In these experiments the earth was employed alone as well as in admixture, the addition being in the one case clay (a white pipe-clay) and in the other lime, the material from which the test-bricks were prepared consisting— ABRASIVE MATERIALS. Infusorial Earth.

In the case of experiment 1. Of the infusorial earth alone.
" " 2. Of a mixture of infusorial earth and clay 95 parts of the former to 5 of the latter.
" " 3. Of a mixture of infusorial earth and clay: 90 parts of the former to 10 of the latter.
" " 4. Of a mixture of infusorial earth and lime: 99 parts of the former to 1 of the latter.
" " 5. Of a mixture of infusorial earth and lime: 98 parts of the former to 2 of the latter.

"The infusorial earth and clay were in an air dried condition; the lime had been but recently prepared. The amount of dried material and water employed to form the various bricks was in all instances the same. The bricks were all moulded of exactly the same size and measured 76 mm. in length, 28 mm. in breath, and 15 mm. in thickness.

"A small hand press was used in the moulding; the pressure employed however, was not great, and did not very much exceed that which might have been obtained by hand. The freshly moulded bricks having been exposed to a dry atmosphere until they had parted with the greater part of their moisture, were next dried at a temperature of 100° C, after which they were inserted in covered crucibles and placed in an air furnace, the temperature of which was gradually raised until at the expiration of an hour a white heat had been obtained, at which temperature it was maintained for an additional two hours.

The experiments were carried out in duplicate with the following results.

"*Refractoriness.*—The bricks had in all instances retained their form perfectly intact; they had neither warped nor cracked; their edges remained perfectly sharp and showed no indication of having undergone even the most incipient fusion. They were all highly absorbent, adhering strongly to the tongue; exceedingly firm and very tough. Bricks of experiments 1, 4 and 5 appeared to possess this latter property in about an equal degree; they could not be readily broken between the fingers; those of experiment 2 broke only with great difficulty, whilst those of experiment 3 could not be broken in this way. The fracture was uneven; in the case of experiments 1, 2 and 3, somewhat jagged. The bricks of experiments 1, 2 and 3 presented very smooth surfaces and possessed a fine and close texture; when suddenly plunged

ABRASIVE MATERIALS.

Infusorial Earth.

into the flame of a blast lamp they decrepitated strongly; this however was not the case when the heat was gradually applied.

"Bricks of experiments 4 and 5 were looser in texture, and when suddenly plunged into the flame of the blast lamp, stood well; they proved excellent non-conductors of heat; the brick could be held between the fingers without the slightest inconvenience whilst the other end was heated to redness in the blast lamp.

"*Contraction.*—The linear contraction (for the temperature and duration of firing afore-specified) amounted to, in the case of test brick,

Of experiment	1....	9·87	per cent of	the original moulded size,
"	2....	11·18	"	"
"	3....	11·18	"	"
"	4....	9·20	"	"
"	5 . .	7·89	"	"

"From this it will be seen that the contraction was most marked in those bricks containing an admixture of clay, and least so in those containing an admixture of lime.

"*Colour.*—The bricks previous to firing were all perfectly white. After firing those of experiments 1, 2 and 3 were of a uniform cream colour, externally and internally. Those of experiments 4 and 5 were perfectly white; this is in accordance with the fact that the presence of the alkaline earths in ferruginous clays, especially of lime and magnesia, has a singular bleaching power in the kiln, arresting the development of the bright red colour. It has been found that a marl containing six per cent of ferric oxide and thirty-five per cent of carbonate of lime, burned of a greyish-buff, instead of the rich red such a proportion of iron would otherwise have produced. Experiment has shown that so small a proportion as five per cent of caustic magnesia mixed with a red clay entirely destroys its red colour in the kiln. In the case of the yellow brick, manufactured in the neighborhood of London, England, the colour is dependent on the admixture of ground chalk with the brick earth, the latter by itself burning of a red colour.

"*Weight.*—As compared with that of a fire brick.—The fire brick measured 9 inches in length, 4½ inches in breadth and 2½ inches in thickness and weighed 7 pounds.

"From the data obtained in these experiments it was found that a brick of the foregoing dimensions, made under the same conditions and from material similar to that employed in the preparation of the test brick,—

ABRASIVE MATERIALS.

Infusorial Earth.

Of experiment	1	would weigh	3	lbs.	6·2	oz.
"	2	"	3	"	10·9	"
"	3	"	3	"	12·4	"
"	4	"	3	"	1·6	"
"	5	"	3	"	1·9	"

"As compared with that of a common brick.—The brick measured 8 inches in length, 3¾ inches in breadth and 2½ inches in thickness and weighed 4 pounds 15 ounces.

"In like manner it was here found that a brick of these dimensions, made under the same conditions and from material similar to that from which the test brick,—

Of experiment	1	was prepared,	would weigh	2	lbs.	10·5	oz.
"	2	"	"	2	"	14·2	"
"	3	"	"	2	"	15·4	"
"	4	"	"	2	"	6·9	"
"	5	"	"	2	"	7·1	"

"The known deposits of importance of diatomaceous earth in Canada are so far confined to the maritime provinces of Nova Scotia and New Brunswick. Deposits of this material are known in other provinces, but the occurrences do not seem to be of economic importance."

Following is an annotated list of deposits, compiled from various sources, but mainly from the reports of the Geological Survey of Canada:—

NOVA SCOTIA.

Nova Scotia.

Cumberland County.—Folly Lake.—The deposit at this place is the largest yet known in Nova Scotia. It occupies the bed and shores of Folly lake, on the Intercolonial railway, at its passage over the Cobequid Mountains. The lake has an area of over 200 acres, two-thirds of which are probably covered with this deposit. Its surface is 600 feet above sea level. The deposit has been worked to a small extent for the manufacture of polishing material and for use as a non-conductor of heat.

Cumberland County.—Fountain Lake.—A valuable deposit of tripolite has been found at this place by Mr. David Grant. It occupies the bed of Fountain lake, on the road to River Philip, West Chester mountains. It is of remarkable purity and the lake is said to be easy to drain. It is eight miles distant from Minas basin at Port au Pic, and about the same distance from the Intercolonial railway. The deposit is worked to a small extent.

ABRASIVE MATERIALS.

Infusorial Earth.

Nova Scotia.

Cobequid Mountains Region.—Other deposits of less extent occur in the numerous lakes of this region.

Pictou County.—Upper Barney River.—In 1886, four tons of infusorial earth were shipped from a deposit at Alex. Sutherland's, in a marsh. The extent of the deposit is not known. The marsh is 50 yards wide and of indefinite length. The deposit of tripolite is two feet thick, and is immediately under the sod.

Cape Breton.—Englishtown.—St. Anns.—A deposit of infusorial earth, said to be of excellent quality, has been largely dug by Mr. F. Torrence. The deposit is in a small lake behind the village.

Inverness County.—River Dennys.—A deposit at this place has had a certain amount of work done on it.

Cumberland County.—Near Castlereagh.—A large deposit of infusorial earth occurs in Bass River Lake. This lake has been drained for the purpose of working the deposit of tripolite.

Victoria County.—St. Anns.—For several years an important deposit of infusorial earth has been worked on a lake near St. Anns. The deposit is from 3 to 4 feet thick and extends over a large area.

Other places at which only preliminary observations have been made and reported as having occurrences of tripolite are :—

Cape Breton County.—Ainsley lake.

Antigonish County.—Lochaber lake.

Pictou County.—Mackay lake.
Black Brook lake.
Garden of Eden lake.
Grant lake.
McLean lake.
Calder lake.
Forbes lake.
Ben lake.
Toney lake.

Colchester County.—Mackintosh lake.
Earltown lake.
Gully lake.

Halifax County.—Grand lake.
Dartmouth lake.

These two lakes supply the city of Halifax with water.

King's County.—Kempt lake.

NEW BRUNSWICK.

ABRASIAE MATERIALS.

Infusorial Earth.

New Brunswick.

Only two important deposits of infusorial earth are known in this province, although there is no doubt that should need arise, other large occurrences would reward careful search.

King's County.—Pollet River lake, Mechanic Settlement.—This deposit covers the bed of the lake and has an average thickness of four feet. A sample from it was the subject of experiments conducted in the laboratory of the Geological Survey, the results of which are given above.

King's County.—Pleasant Lake.—This is situated six miles south-west of Pollet lake. This deposit has not been examined as to its commercial value.

St. John's County.—Lake Fitzgerald.—A very large bed of tripolite occurs at this place. The lake has been drained by the St. John Water Company, exposing a considerable bed of earthy tripolite. According to Mr. Wm. Murdock, C.E., of St. John, the area covered by the deposit is fully fifty acres, and the depth probably reaches fifty feet. The upper layer of this material, about one foot in thickness, is of a light gray colour; on drying it becomes perfectly white. Below this stratum the colour is reddish-brown when fresh, and gray when dry.

QUEBEC.

Quebec.

In the Province of Quebec the deposits of infusorial earth are neither as extensive nor as numerous as in the maritime provinces. The deposits known have not so far been examined very closely as to their economic value, but some may on further investigation prove important

Montmorency County.—Laval Settlement, Range II, Lot 20.—At this place a deposit of infusorial earth occurs, which appears to be extensive. It is found on the right bank of the Bras at its junction with the Montmorency.—The bed is 15 feet thick; is at a height of 40 feet above the river, and is covered by fifty feet of overburden. In colour it is partly yellowish and partly gray.

Portneuf County.—Gosford Township, Range IX. A deposit is known on the east side of the north branch of St. Ann River. This is half an acre in area, four feet thick; the colour of the infusorial earth is a lead gray.

Maskinonge County.—St. Justin, Concession Trompe Souris.—In a sand bank which is sixty to seventy feet high, small quantities of infusorial earth are found a few feet below the surface.

ABRASIVE MATERIALS.

Infusorial Earth.

Quebec.

Montcalm County.—Chertsey Township, Range V, Lot 15. A small deposit of infusorial earth occurs on this lot in the bottom of a marshy bay of Lake Michel. It has an area of three to four acres and a thickness of eighteen inches.

Other deposits are known to occur in the neighborhood of Shawenegan, also on lot 69 of Stoneham, county of Quebec, and another in the valley of the Petawawa river.

In Ontario, a few deposits of infusorial earth are known, but they are unimportant, being small and out of the way.

British Columbia.

BRITISH-COLUMBIA.

Head of Loon Lake.—Interior Plateau of British Columbia. An extensive deposit of this material is said to occur at this place. A sample taken from it was examined by Dr. Hoffmann of the Geological Survey who described it as being * "fine-grained, closely compacted and tough, with a coarse, dull, earthy fracture; is meagre and rough to the feel, adheres strongly to the tongue; colour light reddish. Some slides of this material..........showed it to be almost entirely made up of frustules of diatomaceae.........." This material has been used by the Indians in the vicinity of Cache creek for making tobacco pipes.

Blackwater River, B.C.—The occurrence of a diatomaceous earth in the Tertiary beds on Blackwater river, just above the bridge is referred to by Dr. G. M. Dawson in the Report of the Geological Survey of Canada, 1875-76, p. 256.

Fraser River, B.C.—A deposit of infusorial earth is reported to occur on the south side of the Fraser river opposite Mission City.

Asbestus.

ASBESTUS.

Asbestus was mined and sold in the Eastern Townships, province of Quebec in 1902 to the extent of 30,219 tons valued at $1,126,688, while the production of the short-fibred asbestic was 10,197 tons, valued at $21,631, making a total output of asbestus products of 40,416 tons valued at $1,148,319.

These figures show that the substantial advance made in this industry in 1901, has been well maintained in 1902.

* Report Geol. Survey of Canada, Vol. V, part R, p. 20.

A considerable amount of prospecting has been undertaken during the year and some new ground opened up, while several companies have been engaged in the erection of new mills which will place them in a position to increase considerably their output during the present year. The Canadian product, of the higher grades, is almost altogether exported, finding a market in the United States, England and on the continent of Europe. ASBESTUS.

Statistics of production, exports and imports are given in Tables 1 2, 3 and 4, following :

TABLE 1.

ASBESTUS.

PRODUCTION.—1896 TO 1902. Production.

——	Tons.	Value.	Average Value per ton.
1896—Asbestus	10,892	$ 423,066	$ 38.84
Asbestic	1,358	6,790	5.00
	12,250	$ 429,856	$ 35.09
1897—Asbestus	13,202	$ 399,528	$ 30.26
Asbestic	17,240	45,840	2.66
	30,442	$ 445,368	$ 14.63
1898—Asbestus	16,124	$ 475,131	$ 29.46
Asbestic	7,661	16,066	2.10
	23,785	$ 491,197	$ 20.65
1899—Asbestus	17,790	$ 468,635	$ 26.34
Asbestic	7,746	17,214	2.22
	25,536	$ 485,849	$ 19.03
1900—Asbestus	21,621	$ 729,886	$ 33.76
Asbestic	7,520	18,545	2.46
	29,141	$ 748,431	$ 25.68
1901—Asbestus	32,892	$ 1,248,645	$ 37.96
Asbestic	7,325	11,114	1.52
	40,217	$ 1 259,759	$ 31.32
1902—Asbestus	30,219	$ 1,126,688	$ 37.28
Asbestic	10,197	21,631	2.12
	40,416	$ 1,148,319	28.41

Asbestus.

Production, etc.

TABLE 2.

ASBESTUS.

PRODUCTION, ETC.—1880 TO 1895.

Calendar Year.	Production. Tons (2,000 lbs.)	Value.	Average value per ton.	Exports, Average value per ton.
		$	$ cts.	$ cts.
1880	380	24,700	65.00	Exports taken as production.
1881	540	35,100	65.00	
1882	810	52,650	65.00	
1883	955	68,750	71.98	
1884	1,141	75,097	65.80	
1885	2,440	142,441	58.37	
1886	3,458	206,251	59.64	
1887	4,619	226,976	49.14	63.25
1888	4,404	255,007	57.90	70.56
1889	6,113	426,554	69.77	64.44
1890	9,860	1,260,240	127.81	75.52
1891	9,279	999,878	107.75	70.07
1892	6,082	390,462	64.19	69.35
1893	6,331	310,156	49.02	57.24
1894	7,630	420,825	55.15	59.82
1895	8,756	368,175	42.05	56.66

Exports.

TABLE 3.

ASBESTUS.

EXPORTS.

Calendar Year.	Tons.	Value,	Average value per ton.
1892	5,380	$373,103	$69.35
1893	5,917	338,707	57.24
1894	7,987	477,837	59.82
1895	7,442	421,690	56.66
1896	11,842	567,967	47.96
1897	15,570	473,274	30.40
1898	15,346	494,012	32.19
1899	17,883	473,148	26.46
1900	16,993	693,105	39 61
1901	32,269	1,069,918	33.16
1902	31,074	995,071	32.02

ASBESTUS.

Imports.

TABLE 4.

ASBESTUS.

IMPORTS.

Fiscal Year.	Value.
1885	$ 674
1886	6,831
1887	7,836
1888	8,793
1889	9,943
1890	13,250
1891	13,298
1892	14,090
1893	19,181
1894	20,021
1895	26,094
1896	23,900
1897	19,032
1898	26,389
1899	32,607
1900	43,455
1901	50,829
*1902	52,464

*Asbestus in any form other than crude. and all manufactures of. Duty 25 p.c.

The asbestus production in Canada is confined almost entirely to the province of Quebec, in the district around Black Lake, Thetford and Danville in the Eastern Townships. The asbestus, (or more properly chrysotile) is found in serpentine areas,occurring at intervals along a belt of country extending from the Vermont boundary to the Gaspé Peninsula. The economic occurrences of the mineral, however, are restricted to the districts mentioned above. The mineral is met with in small veins distributed throughout the rock, and mining is conducted in almost every case by open quarrying, some of the workings having now attained considerable depth. The rock mined is submitted to crushing and the asbestus is then separated, sorted and graded according to the length of fibre, by the aid of special machinery.

Asbestus is also found in some serpentines of the Laurentian areas, as for example at Point au Chêne, in Argenteuil county where a mill was formerly erected, but has since been removed, and also in Denholm township, and at other points in the counties of Wright and Labelle.

Following is a list of firms engaged in mining asbestus:

Bell's Asbestus Co., Ltd.—
Geo. R. Smith, Mgr....... Thetford Mines, Que.

King Bros.—
B. Bennett, Mgr .... " " "

ASBESTUS.

Johnson's Co.................Thetford Mines, Que.

Beaver Asbestus Co., Ltd.—
C. H. Van Nostrand, Sec'y..220 Broadway, New York.

Standard Asbestus Co—
R. T. Hopper...............Montreal, Que.

Manhattan Asbestus Co ..... Black Lake, Que.

Canadian Asbestus Co.—
B. Marcuse, Secy............Montreal, Que.

Union Asbestus Mine.........Black Lake, Que.

James Reed, M.D............Reedsdale, Que.

W. R. Kerr & Co..............Black Lake, Que.

Asbestus and Asbestic Co. Ltd...Danville, Que.

East Broughton Asbestus
Mining Co.............East Broughton Sta., Que.

Brompton Lake Asbestus Co.—
B. Greenshields.............Montreal, Que.

Ottawa Asbestus Mining Co....Ottawa, Ont.

Chromite.

CHROMITE.

The production of chromite or chromic iron ore in 1902, was 900 tons, valued at $13,000. The output as usual was obtained chiefly from the township of Coleraine, county of Megantic, Quebec, and shipped from Coleraine and Black Lake stations on the Quebec Central railway.

The greater part of the production goes to the United States, and is used in the manufacture of chromic acid and for furnace linings, &c., while small quantities have been used at Buckingham during the past year or two in the manufacture of ferro-chrome. According to returns of railway shipments, 83 tons of ferro-chrome were shipped from Buckingham during 1902, as compared with 182 tons in 1901.

Statistics of production and exports are given in the following tables :

CHROMITE.

Production.

TABLE 1.

CHROMITE.

ANNUAL PRODUCTION.

Calendar Year.	Tons. (2,000 lbs.)	Average price per ton.	Value.
		$ cts	$
1886	* 60	15 75	945
1887	38	15 00	570
1888 to 1893	no output		
1894	1,000	20 00	20,000
1895	3,177	13 00	41,300
1896	2,342	11 53	27,004
1897	2,637	12 31	32,474
1898	*2,021	12 00	24,252
1899	2,010	10 86	21,842
1900	2,335	11 56	27,000
1901	1,274	13 14	16,744
1902	900	14 44	13,000

* Railway shipments.

Exports.

TABLE 2.

CHROMITE.

EXPORTS.

Calendar Year.	Tons.	Value.
1895	2,908	$ 42,236
1896	2,466	31,411
1897	2,106	26,254
1898	1,683	20,783
1899	1,509	19,876
1900	368	8,259
1901	2,259	25,444
1902	740	7,535

Following is a list of the principal companies interested in the mining of chromite:—

International Chrome Mining and Milling Co. ....Black Lake, Que.
Coleraine Chrome Co., W. H. Lambly..Inverness, Que.
Messrs. Nadeau & Topping ....Black Lake, Que.
Montreal Chrome Iron Co., H. Leonard..D'Israeli, Que.
American Chrome Co...............Black Lake, Que.

Coal.

COAL.

The principal coal-bearing areas at present worked in Canada are the Nova Scotia coal fields in rocks of Carboniferous age, the Cretaceous coals of Vancouver island and the more recently opened fields of the Crows Nest Pass B.C., also found in the Cretaceous rocks.* In Alberta, mining is being done in several different areas, Canmore, Lethbridge and Frank being the chief centres of activity. Lignite of good quality is also mined in the Souris river district, Assiniboia, and during the past two years small amounts have been mined in the Yukon district.

The total production of coal in 1902 was 7,193,142 tons (of 2,000 lbs.) valued at $14,478,181, constituted as follows :—

	Tons.
Bituminous and lignite	7,176,592
Anthracite........................	16,550

The anthracite coal was mined in the Cascade Coal Basin, Alberta, the mine being situated at Anthracite on the main line of the Canadian Pacific Railway.

Compared with the previous year, the production of coal in Canada in 1902 shows an increase of 965,790 tons or over 15 per cent in quantity and $2,472,616 or over 20 per cent in value.

The output is the largest that has yet been attained in Canada and is over twice the production of seven years ago.

Statistics of production are given in Tables 1, 2 and 3, following :—

Production.

TABLE 1.

COAL.

PRODUCTION BY PROVINCES, 1900, 1901 and 1902.

Province.	1900.		1901.		1902.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.
		$		$		$
Nova Scotia.....	3,623,536	8,088,250	4,158,068	6,496,982	5,161,316	9,216,636
British Columbia	1,623,180	4,347,804	1,660,515	4,447,809	1,534,902	4,111,344
North-west Territories including Yukon	351,950	839,375	391,139	1,008,917	478,129	1,110,521
New Brunswick.	10,000	15,000	17,630	51,857	18,795	39,680
Total.......	5,608,666	13,290,429	6,227,352	12,005,565	7,193,142	14,478,181

* A commencement has been made in coal mining in the Nicola district, B.C.

COAL.
Production.

TABLE 2.

COAL.

PRODUCTION. COMPARISON OF 1901 AND 1902.

Province.	Increase or Decrease.			
	Tons.	Per cent.	Value. $	Per cent.
Nova Scotia	*i* 1,003,248	*i* 24·13	*i* 2,719,654	*i* 41·86
British Columbia....	*d* 125,613	*d* 7·56	*d* 336,465	*d* 7·56
North-west Territories including Yukon	*i* 86,990	*i* 22·24	*i* 101,604	*i* 10·07
New Brunswick.............	*i* 1,165	*i* 6·61	*d* 12,177	*d* 23·49
Dominion....	*i* 965,790	*i* 15·51	*i* 2,472,616	*i* 20·59

i Increase. *d* Decrease.

TABLE 3.

COAL.

ANNUAL PRODUCTION SHOWING THE INCREASE OR DECREASE EACH YEAR

Calendar Year.	Tons.	Value.	Average Value per Ton.	Increase (*i*) or Decrease (*d*) in Tonnage.	Incr. (*i*) or Decr. (*d*) per cent.
1886.....	2,116,653	$3,739,840	$1 77	....	....
1887.....	2,429,330	4,388,206	1 81	*i* 312,677	*i* 14·8
1888.....	2,602,552	4,674,140	1 80	*i* 173,222	*i* 7·1
1889.....	2,658,303	4,894,287	1 84	*i* 55,751	*i* 2·1
1890.....	3,084,682	5,676,247	1 84	*i* 426,379	*i* 16·0
1891.....	3,577,749	7,019,425	1 96	*i* 493,067	*i* 16·0
1892....	3,287,745	6,363,757	1 94	*d* 290,004	*d* 8·1
1893. ...	3,783,499	7,359,080	1 95	*i* 495,754	*i* 15·1
1894. ...	3,847,070	7,429,468	1 93	*i* 63,571	*i* 1·7
1895.....	3,478,344	6,739,153	1 94	*d* 368,726	*d* 9·6
1896.....	3,745,716	7,226,462	1 93	*i* 267,372	*i* 7·7
1897.....	3,786,107	7,303,597	1 93	*i* 40,391	*i* 1·1
1898.....	4,172,582	8,222,878	1 97	*i* 386,475	*i* 10·2
1899.....	4,925,051	10,283,497	2 09	*i* 752,469	*i* 18·0
1900.....	5,608,666	13,290,429	2 37	*i* 683,615	*i* 13.9
1901.....	6,227,352	12,005,565	1 93	*i* 618,686	*i* 11·04
1902.....	7,193,142	14,478,181	2 01	*i* 965,790	*i* 15·51

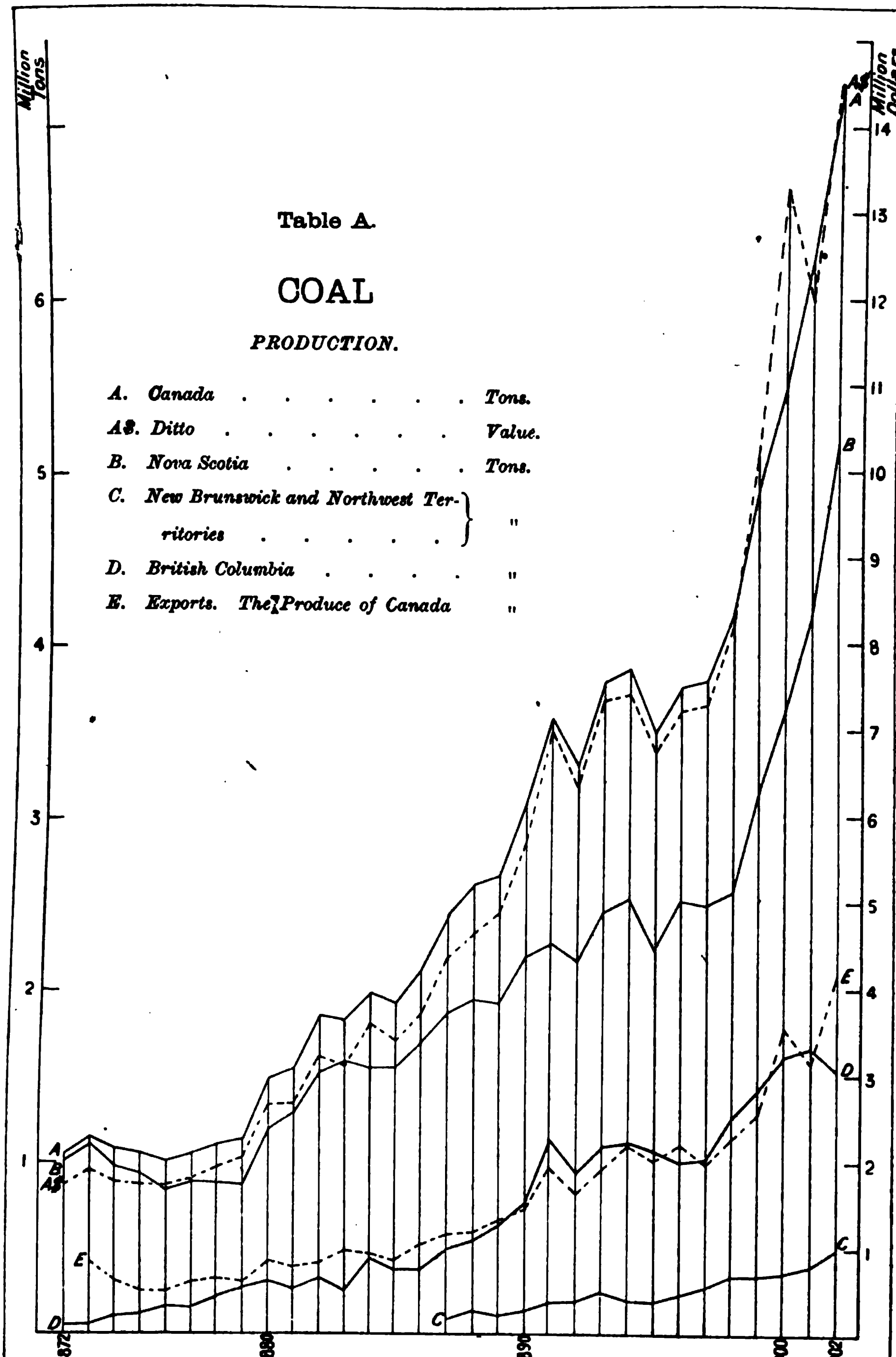


Table A.
COAL
PRODUCTION.
A. Canada . . . . Tons.
A$. Ditto . . . . Value.
B. Nova Scotia . . . . Tons.
C. New Brunswick and Northwest Territories . . . . . . "
D. British Columbia . . . . . "
E. Exports. The Produce of Canada "
Million Tons
Million Dollars
1872
1880
1890
1900
1902

The percentage of production to be credited to the several provinces at various periods since 1874 is shown in the following table :— COAL.

Province.	1874.	1880.	1890.	1898.	1899.	1900.	1901.	1902.
	p. c.	p. c.	p. c.	p. c.	p. c.	p. c.	p. c.	p. c.
Nova Scotia..............	91	79	71	61·4	63·9	64·6	66·8	71·8
British Columbia..........	8	20	25	30·3	29·0	28·9	25·7	21·3
Northwest Territories } New Brunswick. } ..	.....	......	4	8·3	7·1	6·5	6·5	6·9

Statistics of exports and imports are given in the following five tables :

TABLE 4.

COAL.

EXPORTS.

Exports.

Calendar Year.	Produce of Canada.	Not Produce.	Calendar Year.	Produce of Canada.	Not Produce.
	Tons.	Tons.		Tons.	Tons.
1873.........	420,683	5,403	1888.........	588,627	84,316
1874.........	310,988	12,859	1889.........	665,315	89,294
1875.........	250,348	14,026	1890.........	724,486	82,534
1876.........	248,638	4,995	1891.........	971,259	77,827
1877.........	301,317	4,829	1892.........	823,733	93,988
1878.........	327,959	5,468	1893.........	960,312	102,827
1879.........	306,648	8,468	1894.........	1,103,694	89,786
1880.........	432,188	14,217	1895.........	1,011,235	96,836
1881.........	395,382	14,245	1896.........	1,106,661	116,774
1882.........	412,682	37,576	1897.........	986,130	101,848
1883.........	486,811	44,388	1898.........	1,150,029	99,189
1884.........	474,405	62,665	1899.........	1,293,169	101,004
1885.........	427,937	71,003	1900.........	1,787,777	62,776
1886......	520,703	78,443	1901.........	1,573,661	53,894
1887.........	580,965	89,098	1902.........	2,090,268	23,453

COAL.

Exports.

TABLE 5.

COAL.

EXPORTS.—NOVA SCOTIA AND BRITISH COLUMBIA.

Calendar Year.	Nova Scotia.		*British Columbia.	
	Tons.	Value.	Tons.	Value.
1874	252,124	$647,539	51,001	$ 278,180
1875	179,626	404,351	65,842	356,018
1876	126,520	263,543	116,910	627,754
1877	173,389	352,453	118,252	590,263
1878	154,114	293,795	165,734	698,870
1879	113,742	203,407	186,094	608,845
1880	199,552	344,148	219,878	775,008
1881	193,081	311,721	187,791	622,965
1882	216,954	390,121	179,552	628,437
1883	192,795	336,088	271,214	946,271
1884	222,709	430,330	245,478	901,440
1885	176,287	349,650	250,191	1,000,764
1886	240,459	441,693	274,466	960,649
1887	207,941	390,738	356,657	1,262,552
1888	165,863	330,115	405,071	1,605,650
1889	186,608	396,830	470,683	1,918,263
1890	202,387	426,070	508,882	1,977,191
1891	194,867	417,816	767,734	2,958,695
1892	181,547	407,980	599,716	2,317,734
1893	203,198	470,695	708,228	2,693,747
1894	310,277	633,398	770,439	2,855,216
1895	241,091	534,479	728,283	2,692,562
1896	380,149	787,270	679,799	2,507,752
1897	307,128	642,754	630,341	2,221,737
1898	309,158	629,363	813,843	2,948,428
1899†	459,260	827,941	781,809	2,947,369

*See foot-note, table 16.

†Since 1899, exports by provinces have not been published in Trade and Navigation Report.

Coal.

Imports of bituminous.

TABLE 6.

COAL.

IMPORTS OF BITUMINOUS COAL.

Fiscal Year.	Tons.	Value.	Fiscal Year.	Tons.	Value.
1880	457,049	$1,220,761	1892	1,615,220	$4,099,221
1881	587,024	1,741,568	1893	1,603,154	3,967,764
1882	636,374	1,992,081	1894	1,359,509	3,315,094
1883	911,629	2,996,198	1895	1,444,928	3,321,387
1884	1,118,615	3,613,470	1896	1,538,489	3,299,025
1885	1,011,875	3,197,539	1897	1,543,476	3,254,217
1886	930,949	2,591,554	1898	1,684,024	3,179,595
1887	1,149,792	3,126,225	1899	2,171,358	3,691,946
1888	1,231,234	3,451,661	1900	2,439,764	4,310,964
1889	1,248,540	3,255,171	1901	2,516,392	4,956,025
1890	1,409,282	3,528,959	1902*	3,047,392	5,712,058
1891	1,598,855	4,060,896			

*Duty, 53c. per ton.

Imports of anthracite.

TABLE 7.

COAL.

IMPORTS OF ANTHRACITE COAL.

Fiscal Year.	Tons.	Value.	Fiscal Year.	Tons.	Value.
1880	516,729	$1,509,960	1892	1,479,106	$5,640,346
1881	572,092	2,325,937	1893	1,500,550	6,355,285
1882	638,273	2,666,356	1894	1,530,522	6,354,040
1883	754,891	3,344,936	1895	1,404,342	5,350,627
1884	868,000	3,831,283	1896	1,574,355	5,667,096
1885	910,324	3,909,844	1897	1,457,295	5,695,168
1886	995,425	4,028,050	1898	1,460,701	5,874,685
1887	1,100,165	4,423,062	1899	1,745,460	6,490,509
1888	†2,138,627	5,291,875	1900	1,654,401	6,602,912
1889	1,291,705	5,199,481	1901	1,933,283	7,923,950
1890	1,201,335	4,595,727	1902*	1,652,451	7,021,939
1891	1,399,067	5,224,452			

*Coal anthracite, and anthracite coal dust. Duty free.

†In Table 7, Imports of Anthracite Coal, a very considerable increase will be noticed in 1888 over 1887, an increase of over ninety-four per cent, the falling off again in 1889 being quite as remarkable. The average values per ton for the three years 1887, 1888 and 1889, were $4.02, $2.47 and $4.03 respectively. Although a duty of fifty cents per ton on anthracite coal was removed May 13, 1887, it is hardly thought this would account for the changes indicated, and unless some error may possibly have crept into the Trade and Navigation Report, no explanation is available.

COAL.

Imports of dust.

TABLE 8.

COAL.

IMPORTS OF COAL DUST.

Fiscal Year.	Tons.	Value.	Fiscal Year.	Tons.	Value.
1880.........	3,565	$ 8,877	1892.........	82,091	$39,840
1881.........	337	666	1893.........	109,585	44,474
1882.........	471	900	1894.........	117,573	49,510
1883.........	8,154	10,082	1895.........	181,318	52,221
1884.........	12,782	14,600	1896.........	210,386	53,742
1885.........	20,185	20,412	1897.........	225,562	59,609
1886.........	36,230	36,996	1898.........	229,445	45,556
1887.........	31,401	33,178	1899.........	276,547	44,717
1888.........	28,808	34,730	1900.........	330,174	98,349
1889.........	39,980	47,139	1901.........	414,432	275,559
1890.........	53,104	29,818	1902*.........	489,548	264,550
1891.........	60,127	36,130			

*Duty, 20 p. c., not over 13c. per ton.

An approximation of the consumption of coal in Canada sufficiently accurate for purposes of comparison may be made as follows, if we assume the figures of imports for the fiscal year to represent closely enough the importation during the calendar year.

	Tons.	Tons.
Production, Table 3.........................	7,193,142	
Exports of coal the produce of Canada, Table 4	2,090,268	
Home consumption of Canadian coal......................		5,102,874
Imports of bituminous, anthracite and coal dust Tables 6, 7 and 8.........................	5,189,391	
Exports of coal not the product of Canada....	23,453	
Home consumption of imported coal.....................		5,165,938
Total consumption of coal in Canada, home and imported...		10,268,812

Table 9 embodies similar calculations for each year since 1886. Therein is shown the consumption of Canadian and imported coal and the percentage of each as well as the total production per capita. It will be seen that not only the total consumption, but the consumption per capita also has been steadily increasing.

It will be observed too that the proportion of the consumption mined in Canada was greater in 1902 than in any previous year.

An examination of the relation of the total production in Canada, to the amount of coal consumed in the country shows, that in 1902

the production amounted to over 70 per cent of the consumption as compared with 65.8 per cent in 1901 and 68.5 per cent in 1900. In 1890 the proportion was 62.4 per cent, and in 1886, 60.8 per cent. COAL.

TABLE 9.

COAL.

CONSUMPTION OF COAL IN CANADA. Consumption.

Calendar Year	Canadian.	Imported.	Total.	Percentage Canadian.	Percentage Imported.	Consumption per capita.
	Tons.	Tons.	Tons.			Tons.
1886.........	1,595,950	1,884,161	3,480,111	45·9	54·1	·758
1887.........	1,848,365	2,192,260	4,040,625	45·7	54·3	·871
1888.........	2,013,925	3,314,353	5,328,278	37·8	62·2	1·137
1889.........	1,992,988	2,490,931	4,483,919	44·4	55·6	·946
1890.........	2,360,196	2,581,187	4,941,383	47·8	52·2	1·031
1891.........	2,606,490	2,980,222	5,586,712	46·7	53·3	1·153
1892.........	2,464,012	3,082,429	5,546,441	44·4	55·6	1·133
1893.........	2,823,187	3,110,462	5,933,649	47·6	52·4	1·198
1894.........	2,743,376	2,917,818	5,661,194	48·5	51·5	1·130
1895.........	2,467,109	2,933,752	5,400,861	45·7	54·3	1·066
1896.........	2,639,055	3,206,456	5,845,511	45·1	54·9	1·140
1897.........	2,799,977	3,124,485	5,924,462	47·3	52·7	1·143
1898.........	3,022,553	3,274,981	6,297,534	48·0	52·0	1·200
1899.........	3,631,882	4,092,361	7,724,243	47·0	53·0	1·454
1900.........	3,820,889	4,361,563	8,182,452	46·7	53·3	1·521
1901.........	4,653,691	4,810,213	9,463,904	49·1	50·9	1·761
1902.........	5,102,874	5,165,938	10,268,812	49·7	50·3	1·877

NOVA SCOTIA. Nova Scotia.

Detailed statistics of the production of coal in the province are given in Tables 10, 11, 12 and 13.

The production amounted in 1902 to 5,161,316 tons, being an increase over that of the previous year of over 24 per cent. The average value of the production for the year was about $2 per long ton.

COAL.
Nova Scotia.

TABLE 10.

COAL.

NOVA SCOTIA:—OUTPUT, SALES, COLLIERY CONSUMPTION, AND PRODUCTION.

Calendar Year.	Output, Tons, 2,240 lbs.	Sales, Tons, 2,240 lbs.	Colliery Consumption, Tons, 2,240 lbs.	Production* Tons 2,240 lbs.	Output, Tons, 2,000 lbs.	Sales, Tons, 2,000 lbs.	Colliery Consumption, Tons. 2,000 lbs.	Production* Tons, 2,000 lbs.	Price per Ton. 2,240 lbs.	Value of production.
1872	880,950	785,914	110,341	896,255	986,664	880,224	123,582	1,003,806	$1 75	$1,568,446
1873	1,051,467	881,106	108,398	989,504	1,177,643	986,839	121,406	1,108,245	1 75	1,731,632
1874	872,720	749,127	119,582	868,709	977,446	839,022	133,932	972,954	1 75	1,520,240
1875	781,165	706,795	124,110	830,905	874,905	791,610	139,003	930,613	1 75	1,454,084
1876	709,646	634,207	113,788	747,995	794,804	710,312	127,443	837,755	1 75	1,308,991
1877	757,496	687,065	98,841	785,906	848,396	769,513	110,702	880,215	1 75	1,375,339
1878	770,603	693,511	88,627	782,138	863,075	776,732	99,262	875,994	1 75	1,368,741
1879	788,271	688,624	84,787	773,411	882,863	771,259	94,961	866,220	1 75	1,353,469
1880	1,032,710	954,659	96,831	1,051,490	1,156,635	1,069,218	108,451	1,177,669	1 75	1,840,108
1881	1,124,270	1,035,014	107,888	1,142,902	1,259,183	1,159,216	120,834	1,280,050	1 75	2,000,079
1882	1,365,811	1,250,179	111,381	1,361,560	1,529,708	1,400,200	124,747	1,524,947	1 75	2,382,730
1883	1,422,553	1,297,523	111,949	1,409,472	1,593,259	1,453,226	125,383	1,578,609	1 75	2,466,576
1884	1,389,295	1,261,650	116,769	1,378,419	1,556,011	1,413,048	130,781	1,543,829	1 75	2,412,233
1885	1,352,205	1,254,510	127,624	1,382,134	1,514,470	1,405,051	142,939	1,547,990	1 75	2,418,735
1886	1,502,611	1,373,666	142,421	1,516,087	1,682,924	1,538,506	159,512	1,698,018	1 75	2,653,152
1887	1,670,830	1,519,684	139,777	1,659,461	1,871,330	1,702,046	156,550	1,858,596	1 75	2,904,057
1888	1,776,128	1,576,692	157,443	1,734,135	1,989,263	1,765,895	176,336	1,942,231	1 75	3,034,735
1889	1,756,279	1,555,107	158,131	1,713,238	1,967,032	1,741,720	177,107	1,918,827	1 75	2,998,167
1890	1,984,001	1,786,111	161,240	1,947,351	2,222,081	2,000,444	180,589	2,181,033	1 75	3,407,864
1891	2,044,784	1,849,945	174,983	2,024,928	2,290,158	2,071,938	195,981	2,267,919	1 75	3,543,624
1892	1,942,780	1,752,934	175,092	1,928,026	2,175,913	1,963,286	196,103	2,159,389	1 75	3,374,046
1893	2,223,042	1,977,543	205,425	2,182,968	2,489,807	2,214,848	230,076	2,444,924	1 75	3,820,194
1894	2,250,631	2,060,920	196,206	2,257,126	2,520,707	2,308,231	219,751	2,527,982	1 75	3,949,970
1895	1,999,756	1,793,098	193,639	1,986,737	2,239,727	2,008,270	216,875	2,225,145	1 75	3,476,790
1896	2,292,675	2,046,828	192,975	2,239,803	2,567,796	2,292,447	216,132	2,508,579	1 75	3,919,655
1897	2,340,031	2,044,672	181,716	2,226,388	2,620,835	2,290,032	203,522	2,493,554	1 75	3,896,179
1898	2,262,656	2,121,126	167,428	2,288,554	2,534,175	2,375,661	187,519	2,563,180	1 75	4,004,970
1899	2,865,443	2,633,989	177,460	2,811,449	3,209,296	2,950,067	198,755	3,148,822	2 00	5,622,898
1900	3,298,791	2,998,737	236,563	3,235,300	3,694,646	3,358,585	264,951	3,623,536	2 50	8,088,250
1901	3,821,033	3,411,127	301,434	3,712,561	4,279,557	3,820,462	337,606	4,158,068	1 75	6,496,982
1902	4,725,480	4,229,120	379,198	4,608,318	5,292,538	4,736,614	424,702	5,161,316	2 00	9,216,636

* This Production is obtained by adding Sales and Colliery Consumption. For sales previous to 1872, see report of the Department of Mines Nova Scotia, 1883, page 68.

COAL.
Nova Scotia.

TABLE 11.

COAL.

NOVA SCOTIA :—COAL TRADE BY COUNTIES.

CALENDAR YEAR.	CUMBERLAND.		PICTOU.		CAPE BRETON.		OTHER COUNTIES.	
	Raised.	Sold.	Raised.	Sold.	Raised.	Sold.	Raised.	Sold.
	Tons, 2,000 lbs.	Tons, 2,000 lbs.	Tons, 2,000 lbs.	Tons, 2,000 lbs.	Tons, 2,000 lbs.	Tons, 2,000 lbs.	Tons, 2,000 lbs.	Tons, 2,000 lbs.
1st quarter....	150,993	111,097	126,349	103,482	783,718	567,542	20,043	16,214
2nd "	143,515	126,137	142,015	129,274	950,189	886,849	33,648	22,976
3rd "	163,862	151,087	174,944	164,203	1,088,652	1,106,589	37,050	30,770
4th "	163,421	150,664	191,997	173,181	1,064,344	950,266	57,798	46,283
Total, 1902..........	621,791	538,985	635,305	570,140	3,886,903	3,511,246	148,539	116,243
" 1901..........	538,773	447,616	533,840	460,349	3,116,641	2,888 610	40,303	23,887

COAL.

Nova Scotia.

TABLE 12.

COAL.

NOVA SCOTIA:—OUTPUT BY COLLIERIES DURING THE CALENDAR YEAR, 1902.

Colliery.	Tons, 2,000 lbs.	Colliery.	Tons, 2,000 lbs.
Cumberland County.		*Inverness County.*	
Chignecto............ ..	4,607	Mabou	1,120
Joggins....	58,580	Pt. Hood	57,188
Jubilee...........	883	Broad Cove.............	76,749
Scotia..................	1,047	*Victoria County.*	
Springhill	554,322		
Strathcona.........	2,352	New Campbelton....... ..	13,481
		Cape Breton County.	
		Dominion Coal Co.........	3,555,134
Pictou County.		Nova Scotia Steel and Coal Co.....................	296,338
Acadia..................	357,418	Gowrie and Blockhouse....	26,208
Nova Scotia Steel and Coal Co	35,766	Sydney.........	9,223
Intercolonial............	242,122	Total..............	5,292,538

TABLE 13.

COAL.

NOVA SCOTIA:—DISTRIBUTION OF COAL SOLD.

Markets.	Calendar Years.			
	1901.		1902.	
	Tons, 2,000 lbs.	Per cent.	Tons, 2,000 lbs.	Per cent.
Nova Scotia, transported by land.....	757,975	19·8	468,658	9·9
" " sea......	533,569	14·0	1,175,644	24·8
Total, Nova Scotia...........	1,291,544	33·8	1,644,302	34·7
New Brunswick.....................	366,976	9·6	358,664	7·6
Prince Edward Island..............	78,324	2·1	70,316	1·5
Quebec	1,315,935	34·4	1,492,902	31·5
Newfoundland......................	124,265	3·3	118,041	2·5
United States.....	623,390	16·3	1,004,650	21·2
West Indies........................	....	....	6,700	·1
Other countries....	20,028	·5	41,039	·9
Total........................	3,820,462	100·0	4,736,614	100·0

New Brunswick.

NEW BRUNSWICK.

The production of coal in this province in 1902 was 18,795 tons valued at $39,680, a slight increase in quantity over the previous year, but realizing a somewhat lower price per ton at the mines.

TABLE 14.

COAL.

NEW BRUNSWICK:—PRODUCTION.

COAL.

New Brunswick.

Calendar Year.	Tons.	Value.	Value per ton.
1887	10,040	$ 23,607	$2 35
1888	5,730	11,050	1 93
1889	5,673	11,733	2 07
1890	7,110	13,850	1 95
1891	5,422	11,030	2 03
1892	6,768	9,375	1 39
1893	6,200	9,837	1 59
1894	6,469	10,264	1 59
1895	9,500	14,250	1 50
1896	7,500	11,250	1 50
1897	6,000	9,000	1 50
1898	6,160	9,240	1 50
1899	10,528	15,792	1 50
1900	10,000	15,000	1 50
1901	17,630	51,857	2 94
1902	18,795	39,680	2 11

NORTHWEST TERRITORIES.

Northwest Territories.

One of the main features to record, in connection with coal mining operations in the North-west Territories in 1902 is the large output of coal from the new collieries at Frank, Alberta, on the Crows Nest Pass branch of the Canadian Pacific Railway.

The total product of the Territories for the year has been returned as 478,129 tons valued at $1,110,521 and made up as follows :*—

	Tons.
Estevan and Coalfields	70,400
Lethbridge	153,703
Miscellaneous small mines	15,841
Anthracite and Canmore	107,950
Frank and Blairmore	125,325
Yukon district	4,910
	478,129

Of this amount 16,550 tons is anthracite coal and the balance bituminous and lignite.

* Since writing the above the annual report of the Department of Public Works of the Northwest Territories for 1902 has been received in which the output of the coal mines of the Territories (not including the Yukon) is given as:—

Bituminous and lignite	494,087 tons
Anthracite coal	16,587 "
total	510,674 "

Although the figures of production in the present report represent sales and shipments only, it is still possible that they are incomplete owing to there being so many producers of coal on a small scale in the Territories.

COAL.

North-west Territories.

TABLE 15.

COAL.

NORTH-WEST TERRITORIES :—PRODUCTION.

Calendar Year.	Tons.	Value.	Value per ton.
1887	74,152	$ 157,577	$ 2 13
1888	115,124	183,354	1 59
1889	97,364	179,640	1 85
1890	128,953	198,498	1 54
1891	174,131	437,243	2 51
1892	184,370	469,930	2 55
1893	238,395	598,745	2 51
1894	199,991	488,980	2 45
1895	185,654	414,064	2 23
1896	225,868	606,891	2 69
1897	267,163	667,908	2 50
1898	340,088	825,220	2 43
1899	334,600	811,500	2 43
1900	351,950	839,375	2 38
1901	391,139	1,008,917	2 58
1902	478,129	1,110,521	2 32

British Columbia.

BRITISH COLUMBIA.

The total sales and shipments including colliery consumption and not including coal used for making coke were in 1902 1,370,448 long tons or 1,534,902 short tons, being a decrease from the previous year of about 7·5 per cent. 244,232 long tons were used for making coke during the year, and 26,946 long tons were added to stock, so that the total output of the collieries for the year was 1,641,626 long tons.

Statistics of output, home consumption, quantity sold for export, etc., are shown in Table 16.

COAL.
British Columbia.

TABLE 16.

COAL.

BRITISH COLUMBIA :—PRODUCTION.

Calendar Year.	Output Tons, 2,240 lbs.	Home Consumption, Tons, 2,240 lbs.	Sold for Export, Tons, 2,240 lbs. ‡	Production.* Tons, 2,240 lbs.	Production.* Tons, 2,000 lbs.	Price per ton, 2,240 lbs.	Value.
						$	$
		From 1836 to 1873 inclusive, the output is taken as production.					
1836-52..	10,000				11,200	4 00	40,000
1852-59..	25,398				28,446	4 00	101,592
1859¶...	1,989				2,228	4 00	7,956
1860.....	14,247				15,957	4 00	56,988
1861.....	13,774				15,427	4 00	55,096
1862.....	18,118				20,292	4 00	72,472
1863.....	21,345				23,906	4 00	85,380
1864.....	28,632				32,068	4 00	114,528
1865.....	32,819				36,757	4 00	131,276
1866....	25,115				28,129	4 00	100,460
1867. ..	31,239				34,988	4 00	124,956
1868.....	44,005				49,286	4 00	176,020
1869.....	35,802				40,098	4 00	143,208
1870.....	29,843				33,424	4 00	119,372
1871-2-3.	148,459				166,274	4 00	593,836
1874.....	81,547	25,023	56,038	81,061	90,788	3 00	243,183
1875.....	110,145	31,252	66,392	97,644	109,361	3 00	292,932
1876.....	139,192	17,856	†122,329	140,185	157,007	3 00	420,555
1877.....	154,052	24,311	115,381	139,692	156,455	3 00	419,076
1878.. ..	170,846	26,166	164,682	190,848	213,750	3 00	572,544
1879.....	241,301	40,294	192,096	232,390	260,277	3 00	697,170
1880. ...	267,595	46,513	225,849	272,362	305,045	3 00	817.086
1881.....	228,357	40,191	189,323	229,514	257,056	3 00	688,542
1882.....	282,139	56,161	232,411	288,572	323,201	3 00	865,716
1883.....	213,299	64,786	149,567	214,353	240,075	3 00	643,059
1884. ...	394,070	87,388	306,478	393,866	441,130	3 00	1,181,598
1885.....	365,596	95,227	237,797	333,024	372,987	3 00	999,072
1886.....	326,636	85,987	249,205	335,192	375,415	3 00	1,005,576
1887.....	413,360	99,216	334,839	434,055	486,142	3 00	1,302,165
1888.....	489,301	115,953	365,714	481,667	539,467	3 00	1,445,001
1889.....	579,830	124,574	443,675	568,249	636,439	3 00	1,704,747
1890.....	678,140	177,075	508,270	685,345	767,586	3 00	2,056,035
1891.....	1,029,097	202,697	806,479	1,009,176	1,130,277	3 00	3,027,528
1892	826,335	196,223	640,579	836,802	937,218	3 00	2,510,406
1893.....	978,294	207,851	768,917	976,768	1,093,980	3 00	2,930,304
1894.....	1,012,953	165,776	827,642	993,418	1,112,628	3 00	2,980,254
1895.....	939,654	188,349	756,334	944,683	1,058,045	3 00	2,834,049
1896.....	894,882	261,984	634,238	896,222	1,003,769	3 00	2,688,666
1897.....	892,296	290,310	619,860	910,170	1,019,390	3 00	2,730,510
1898.....	1,136,015	374,953	752,863	1,127,816	1,263,154	3 00	3,383,448
1899.....	1,306,324	526,058	751,711	1,277,769	1,431,101	3 00	3,833,307
1900. ...	1,590,178	535,084	914,184	1,449,268	1,623,180	3 00	4,347,804
1901. ...	1,691,557	568,440	914,163	1,482,603	1,660,515	3 00	4,447,809
1902.....	1,641,626	593,639	776,809	1,370,448	1,534,902	3 00	4,111,344

*This production is obtained by adding 'Home Consumption' and 'Sold for Export,'

†52,935 of this amount was exported as sales without the division into the 'Home Consumption' and 'Sold for Export.'

‡The figures in the 'Sold for Export' column do not agree as they should with those given in Table 5, the only explanation being that the data in the two cases are from different sources, and it has not been possible to find out the cause of the difference.

¶Two months only.

COAL.

British Columbia.

Statistics of production.

Statistics of coal production in 1902 are given in the Annual Report of the Minister of Mines for the province as follows :

SALES AND OUTPUT FOR YEAR. Tons of 2240 lbs.	Tons.	Cwt.	Tons.	Cwt.
Sold for consumption in Canada	422,466	13		
" export to U.S.A.	775,300	11		
" " to other countries	1,508			
Total sales	1,199,275	04		
Used under colliery boilers &c	171,172	15		
Total sales and colliery consumption	....	.....	1,370,447	19
Used in making coke	....	.....	244,232	
			1,614,679	19
Stock on hand first of year	5,704	17		
" " last of year	32,651			
Difference added to stock during the year	....	.....	26,946	03
Output of collieries for year	....	.....	1,641,626	02

Statistics of labour and wages.

Statistics of labour and wages are given in the same report as follows :

Number of hands employed, daily wages paid etc.

CHARACTER OF LABOUR.	UNDERGROUND.		ABOVE GROUND.		TOTAL.	
	No. of employees	Average daily wage	No. of employees	Average daily wage	No. of employees	Average daily wage
Supervision and clerical assistance	63	$ 4 30	48	$ 4 85	111	$ 4 57
Whites—						
Miners	1,625	4 30	....	....	1,625	4 30
Miners helpers	494	2 40	....	....	494	2 40
Labourers	569	2 73	206	2 34	775	2 53
Mechanics and skilled labour	47	2 81	199	3 10	246	2 95
Boys	133	1 42	23	1 15	156	1 28
Japanese	38	1 37	46	1 12	84	1 24
Chinese	132	1 37	388	1 21	520	1 29
Totals	3,101	....	910	....	4,011	

In view of the fact that 75 per cent of the production of Vancouver island collieries is exported to California, the following statistics of

receipts of coal in the Californian market are given as illustrating the position which British Columbia coal occupies in this market: COAL.

Whence derived.	1901.	1902.
	Tons, 2,240 lbs.	Tons, 2,240 lbs.
British Columbia	710,330	591,732
Australia	175,959	187,328
England and Wales	52,270	95,621
Scotland	....	1,600
Eastern (Cumberland and Anthracite)	27,370	24,133
Seattle (Washington)	240,574	165,237
Tacoma "	433,817	209,358
Mount Diable, Coos Bay and Tesla	143,318	111,209
Japan and Rocky Mountains	51,147	47,380
Totals	1,834,785	1,445,598

Following is a list of the principal coal producers in Canada.

NOVA SCOTIA :—

Inverness Railway and Coal Company..Broad Cove, C.B.
Gowrie and Blockhouse Collieries, Ltd ..Port Morien, C.B.
Mabou Coal Mining Company, Ltd.....Mabou, C.B.
Port Hood Coal Company, Ltd.........Port Hood, C.B.
Cape Breton Coal Mining Co., Ltd......New Campbellton, C.B
Dominion Coal Co., Ltd..............Sydney, C.B.
Sydney Coal Company, Ltd...........Sydney Mines C.B.
Acadia Coal Co., Ltd.................Stellarton, N.S.
Nova Scotia Steel & Coal Co., Ltd......New Glasgow, N.S.
Intercolonial Coal Mining Co., Ltd.....Westville, N.S.
Cumberland Railway and Coal Co., Ltd..Springhill, N.S.
Canada Coals and Railway Co., Ltd....Joggins Mines, N.S.
Minudie Coal Co., Ltd...............River Hebert, N.S.
Strathcona Coal Co...................River Hebert, N.S.
Messrs Ripley and Blenkhorn (Scotia Mine)

NEW BRUNSWICK :—

New Brunswick Coal & Railway Company..Fredericton, N.B.

NORTH WEST TERRITORIES :—

Souris Coal Mining Company, Ltd.....R. R. Taylor, Managing Director, Winnipeg, Man.

COAL.

Coal producers.

P. C. Duncan	Estevan, Assa.
Frank Gillespie	Medicine Hat, Assa.
Joseph Cully	" "
Crockford Bros	" "
Alberta Railway and Coal Co	Lethbridge, Alta.
Alberta Coke and Coal Co., (Martin B. Holway)	Cowley, "
R. J. Galbraith	" "
E. V. Wilson	Livingston, "
Blackfoot Indian Agency, J. A. Markle, agent	Gleichen, "
J. T. Cooper	Calgary, "
J. A. Bangs	" "
F. Barnes	Clover Bar, "
Daly and Lindsay	" "
Keith Fulton and Fowler	" "
E. Chevigny	Morinville, "
Wm. Humberstone	Edmonton, "
Milner and Blatchford	" "
W. J. Baldwin	" "
Bishopric, Grierson and Mays	" "
Leon Moret	Ft. Saskatchewan, Alta
Fishlum and Procter	Blairmore, Alta.
The Canadian Am. Coal and Coke Co	" "
United Gold Fields of British Columbia	" "
International Coal and Coke Co	" "
The H. W. McNeil Co., Ltd	Anthracite "
YUKON DISTRICT :—	
North American Tansportation and Trading Co., Cliff Creek Mines	Dawson.
Alaska Exploration Co., Rock Creek Mine.	"
R. S. Ames and Geo. Miller, Five Fingers Mine	"
BRITISH COLUMBIA :—	
Crows Nest Pass Coal Co., Ltd	Fernie, B.C.
Western Fuel Co	Nanaimo, B.C.
Wellington Colliery Co., Ltd	Victoria, B.C.

COAL.

Coke.

COKE.

Production.

The sales of coke in 1902 amounted to 502,043 tons, valued at $1,519,185, being an increase over the production of the previous year of 136,512 tons, or 37 per cent in quantity, and $290,960, or over 23 per cent in value. The increase is to be all credited to the province of Nova Scotia, there being a slight falling off in British Columbia.

TABLE 1.

COKE.

ANNUAL PRODUCTION.

Calendar Year.	Tons.	Value.	Value. per Ton.
1886	35,396	$101,940	$2 88
1887	40,428	135,951	3 36
1888	45,373	134,181	2 96
1889	54,539	155,043	2 84
1890	56,450	166,298	2 95
1891	57,084	175,592	3 08
1892	56,135	160,249	2 85
1893	61,078	161,790	2 65
1894	58,044	148,551	2 56
1895	53,356	143,047	2 68
1896	49,619	110,257	2 22
1897	60,686	176,457	2 91
1898	87,600	286,000	3 26
1899	100,820	350,022	3 47
1900	157,134	649,140	4 13
1901	365,531	1,228,225	3 36
1902	502,043	1,519,185	3 03

TABLE 2.

COKE.

PRODUCTION OF COKE BY PROVINCES.

Calendar Year.	Nova Scotia.		British Columbia.	
	Tons.	Value.	Tons.	Value.
		$		$
1897	41,532	90,950	19,154	85,507
1898	48,400	111,000	39,200	175,000
1899	62,459	178,767	38,361	171,255
1900	61,767	223,395	95,367	425,745
1901	222,694	590,560	142,837	637,665
1902	363,330	899,930	138,713	619,255

COAL.

Coke.

Exports.

TABLE 3.

COKE.

EXPORTS OF COKE.

Calendar Year.	Tons.	Value.
		$
1897	2,987	6,078
1898	3,774	8,394
1899	5,557	18,726
1900	41,529	131,278
1901	57,505	176,990
1902	62,568	180,920

Imports of oven coke.

TABLE 4.

COKE.

IMPORTS OF OVEN COKE.

Fiscal Year.	Tons.	Value.
		$
1880	3,837	19,353
1881	5,492	26,123
1882	8,157	36,670
1883	8,943	38,588
1884	11,207	44,518
1885	11,564	41,391
1886	11,858	39,756
1887	15,110	56,222
1888	25,487	102,334
1889	29,557	91,902
1890	36,564	133,344
1891	38,533	177,605
1892	43,499	194,429
1893	41,821	156,277
1894	42,864	176,996
1895	43,235	149,434
1896	61,612	203,826
1897	83,330	267,540
1898	135,060	347,040
1899	141,284	362,826
1900	187,378	506,839
1901	308,786	680,138
1902.. ....Duty free.	267,142	842,815

Following is a list of companies making coke in Canada from Canadian coal:—

Nova Scotia.—Acadia Coal Co., Stellarton, N.S.
Intercolonial Coal Mining Co., Westville, N.S.
Nova Scotia Steel and Coal Co., New Glasgow, N.S.
Halifax Electric Tramway Co. (Ltd.), Halifax, N.S.
Dominion Iron and Steel Co. (Ltd.), Sydney, C.B.

British Columbia.—Crows Nest Pass Coal Co. (Ltd.), Fernie, B.C. COAL.
Wellington Colliery Co. (Ltd.), Victoria, B.C. Coke.

The production of coke in British Columbia is given in the provincial report as follows :

Sales and Output for the Year.	Tons, 2,240 lbs.	Tons, 2,240 lbs.
Sold for consumption in Canada......	85,071	
" export to United States.......	38,780	
Total sales	....	123,851
Stock on hand, first of year...... ...	186	
" " last "	4,350	
Diff. added to stock during the year...	....	4,164
Output for year............	....	128,015

Peat.—During the past few years many companies have been Peat. organized to manufacture peat-fuel from peat bogs in the provinces of Ontario and Quebec. Some of these have met with indifferent success, while others are still in the experimental stage or developing their properties.

Sales of peat during the past three years have been reported as follows :—

	Tons.	Value.
Year 1900......	400	$1,200
" 1901	220	660
" 1902.......................................	475	1,663

*The Coal Fields of Canada.

The following short description of the coal fields of Canada will, in connection with the statistics already given, be found illustrative of

*This article appeared originally in the Annual Report of the Mines Section for 1898, constituting Part S, Vol. XI of the reports of the Geological Survey Department. Mr. Denis in compiling the present article has not only brought the information up to date but has very much extended its scope.

COAL.

the coal industry of the country. It has been compiled by Mr Theo. Denis, B. Sc., chiefly from information to be found throughout the Reports of the Geological Survey, supplemented by data taken from other reliable sources. As a guide for reference a full list of the maps published by the Geological Survey of Canada, covering the areas referred to in the course of this summary description has been added at the end of the article; also a list of references forming a short bibliography of the subject. The maps may be obtained from the librarian of the Survey for the nominal sale prices mentioned in the "List of Publications of the Geological Survey of Canada" and Supplement.

The chief fields are located as follows: In Nova Scotia there are several extensive areas of bituminous coal which have been mined for many years. In New Brunswick is a small area with thin seams, also bituminous. The above are all in rocks of Carboniferous age. In Manitoba and the North-west Territories, very large tracts of the prairie country are underlaid by coal beds, varying in quality from lignite in the east to bituminous in the west, as the foot-hills of the Rocky mountains are approached. In the mountain region itself is a small basin where anthracite is mined. Across the watershed in British Columbia is the Crow's Nest Pass field, now being opened up, and on the Pacific coast are the areas on the east side of Vancouver island, that have long been worked. These coal fields are of Cretaceous age. Coals referable to the same period are also found in the Queen Charlotte islands and in many parts of the interior of the province. These Cretaceous coals are generally bituminous, but anthracite occurs in the Queen Charlotte islands. Tertiary fuels also underlie considerable areas in the interior as well as several tracts along the coast. These are usually lignites or brown coals.

Nova Scotia.

NOVA SCOTIA.

The coal-bearing measures of Nova Scotia belong to the Carboniferous, and are practically confined to the one of its subdivisions generally known as the Coal Measures.

The coal mined in this province is all bituminous in quality.

The following sub-divisions into fields is usually adopted:—

1. The Sydney coal field.
2. The Inverness coal field.
3. The Richmond coal field.
4. The Pictou coal field.
5. The Cumberland coal field.

Sydney Coal Field.

COAL.

Nova Scotia.

This field is situated in the north-east corner of Cape Breton county, and takes in a small portion of Victoria county. It occupies a land area of 200 square miles, about 32 miles long by six wide, and is limited on three sides by the Atlantic Ocean. The conditions for extraction and shipment are very favourable. There is a remarkable absence of faults and the coast affords a number of natural harbours. The greater part of the coal-field is hidden beneath the sea, but the seams can be followed under its bed.

*The measures inclosing the Cape Breton coals are largely composed of argillaceous shales and sandstones, the solidity and coherence of which favour submarine exploitation. As to the general structure, it can be said that the seams appear on the shore, sweep inland, and again enter the ocean, forming segments of ellipses whose centres are out at sea. This structure is observable at Cow Bay, Glace Bay, Lingan and Sydney, these places presenting a series of basins, the seams of which have been correlated, and their equivalence in many cases proved. These basins probably owe their origin to a corrugation of the area by numerous folds which bring the same coal seams repeatedly to the surface along the north-east coast of the island.

The whole coast is deeply indented by bays and channels, approximately coinciding with the axes of these folds, and affording in the sea-cliffs numerous natural sections of the strata and exposures of the coal seams. Some of these bays also constitute excellent harbours, one of which—Sydney Harbour—situated towards the centre of the district, ranks among the finest and most commodious on the Atlantic coast of North America. The cliffs are generally from thirty to eighty feet high, standing perpendicularly, or frequently overhanging the sea. The country inland is of a gently rolling character, the maximum height being about 250 feet.

Such natural advantages, combined with its highly favourable geographical position, point to this district as probably the most important in the Dominion for the supply of fuel to steamships navigating the Atlantic. During the few months of winter, when the more northerly harbours are closed or obstructed by ice, an outlet is afforded by the railway connecting many of the collieries with Louisburg, a fine harbour, open and safe for shipping at almost any season.

*See "Descriptive Note on the Sydney coal-field" by Hugh Fletcher B.A., published by the Geological Survey of Canada 1900.

COAL.
Nova Scotia.

The aggregate thickness of coal in workable seams, outcropping on the shore, and for the most part exposed in the bays and cliffs, is from forty to fifty feet; the seams vary from three to nine feet in thickness. They generally dip at very low angles of five to twelve degrees and appear to be very little affected by faults or disturbances. As the strata all dip seaward, much of the coal will be available in the submarine as well as in the land areas. From experience at the Sydney mines it has been fully established that, with due caution and care, these submarine areas may be worked to a large extent.

The coal is of the bituminous or 'soft' variety, with comparatively little diversity in the quality of the different seams; all of which yield a fuel exceedingly well adapted for general purposes, while that of some of them is specially applicable to the manufacture of gas. As compared with the Pictou coal, it is characterized on the whole, by a greater proportion of combustible matter and a smaller proportion of ash; but on the other hand it usually contains a greater amount of sulphur.

The following tabulation, condensed from the work of the Geological Survey shows the equivalency of the different seams of the field at the different places together with the thickness of the intervening strata:

Average thickness.	Cow Bay.	Glace Bay.	Lingan.	Sydney Mines.	Boulardarie.
3 feet	....	....	Seam A	....	Point Aconi.
300 "					
6·5 "	....	....	Carr Seams	Lloyd's Cove	Bonar.
190 "					
12 "	....	Hub	Barrasois.	Seam B.	Stubbart.
350 "					
7 "	Block House	Harbour	David Head	Sydney Main.	Seam C.
275 "					
3 "	Seam D	Bouthillier	Seam D	Bryant.	Mill Pond.
90 "					
4 "	Seam E	Back Pit	North Head	Edward	Black Rock.
110 "					
7 "	McAulay	Phelan	Lingan Main	Seam F.	Seam F.
125 "					
3 "	South Head. Spencer	Ross. Emery	Seam G.	Collins.	Seam G.
320 "					
4 "	Long Beach.	Gardiner	Seam H	....	....

The correctness of the above correlation is, however, questioned by some. The aggregate thickness of coal in the workable beds outcropping on the shore, ranges from thirty feet at some places to sixty at others. Most of the Sydney coals are well suited for the manufacture of gas, as the following figures show:—

COAL.
Nova Scotia.

Mines.	Gas, Cubic Feet per ton.	Candle power.	Coke produced.
Little Glace Bay	9,268	15	40 bush.
" "	9,700	14·75	39 "
International Mine	10,000	16	1,470 lbs.
Sydney Mines	8,200	8	1,295 "
Gowrie "	9,000	15	1,230 "
Caledonia "	8,900	14·25	36 bush.
Reserve "	9,950	13·17	1,500 lbs.

The value of these coals for steam and house purposes is given in the table of analyses at the end of this article, whenever obtainable.

The Sydney coal field was the first one opened in Canada. As early as 1785, work was done on it by the government. This, however, was of a desultory nature. In 1827, systematic and regular mining was begun by the General Mining Association.

The collieries at present in operation in this field are described below. Comparing the descriptions with the tabulation of the seams already given, it will be noted that the greater part of these are not at present under exploitation, although very extensive work has been done at different times on some of them. Should need arise, however, many of these would constitute a very important additional source of supply.

Sydney Mines Colliery.—This colliery was worked by the General Mining Association until 1900, when it was purchased from this corporation by the Nova Scotia Steel and Coal Company. This transaction practically terminated the connection of the General Mining Association with coal mining in Nova Scotia, after a career of nearly three-quarters of a century.

The colliery is situated three miles to the north-east of North Sydney.

Seam, 5 feet 4 inches. Dip 1 in 12.

Shaft, 690 feet deep; 13 feet diameter.

Worked by pillar and stall and longwall. Safety lamps.

Coal produced in 1902, 270,000 tons.*

Average number of persons employed above and underground, 1,000.

North Sydney Colliery.—Operated by the Sydney Coal Company.

Seam, 4 feet.

* These figures of production are only approximate and are here given to illustrate the relative importance of the collieries.

COAL.
Nova Scotia.

Worked by slope, 650 yards.

Method, pillar and stall. Naked lights.

Coal produced in 1902, 7,510 tons. Persons employed, 32.

New Campbellton Colliery.—Operated by the Cape Breton Coal Company.

Situated on the Big Bras d'Or Lake.

Seam, 4 feet; dip, 1 in 5

Slope, 600 yards.

Coal-cutting machines. Method of working, pillar and stall.

Naked lights.

Coal produced in 1902, 13,443 tons. Persons employed, 36.

Gowrie and Block House Collieries.—Situated on Port Morien or Cow Bay. Operated by the Gowrie and Blockhouse Colliery, Limited. This company was organized in 1898, acquiring properties which had been idle for some time. The coal area controlled by this company covers five square miles, comprising leases 193, 146, 194, 206 and 235.

McAulay or Gowrie seam, 5 feet 6 inches. Worked by shaft, 205½ feet deep.

Coal-cutting machines. Coal produced in 1902, 20,000 tons.

Persons employed, 81.

Dominion Coal Company.—This company was incorporated in 1893. It holds a number of leases for a period of ninety-nine years in the coal basins of Cow Bay, Glace Bay and Lingan. The collieries which it is operating at present are enumerated below. Besides these it owns others of importance which are not now working, such as the Victoria, Lingan, Cow Bay and Old Bridgeport, etc. The company has concentrated its operations on the Glace Bay basin, which it has developed to a great extent. The production of the Dominion Coal Company for 1902 amounted to nearly 3,306,000 tons, giving employment to 3,454 persons.

Caledonia Colliery, Glace Bay Basin.—Situated one mile from Little Glace Bay. Phelan seam worked; 7 to 8 feet.

Worked by pillar and room.

Underground haulage by endless rope.

Output for 1900, 573,298 tons.

Reserve Colliery, Glace Bay Basin.—On Phelan seam, 8 feet thick. COAL.

Worked by slopes, pillar and room method. Nova Scotia.

Endless rope haulage. Output for 1900, 707,927 tons.

International Mine, Glace Bay Basin.—Seam worked 'Harbour' 6 feet.

Method, pillar and room. Endless and tail rope systems of haulage.

Three compartment shafts. Output for 1900, 249,427 tons.

Dominion No. 1, Glace Bay Basin.—On Phelan seam. Dip, 1 in 14. Worked by pillar and room. Electric underground haulage.

Output for 1900, 602,825.

Dominion No. 2, Glace Bay Basin.—This colliery was opened in 1900. The shaft is a four compartment one, 37′ 11″ down to 410 feet where it strikes the Harbour seam and is reduced to 21′ 11″ down to 850 feet where it strikes the Phelan seam.

Harbour seam 6½ feet, Phelan seam 8 feet.

This mine is equipped for a daily output of 6,000 tons.

Dominion No. 3, Glace Bay Basin.—Opened on Phelan seam in 1900. Mined by pillar and room method.

Entered by slopes two miles from Caledonia Colliery. Endless rope haulage. In 1902, the output of this mine had increased to 1900 tons a day.

Dominion No. 4, Glace Bay Basin.—Slope driven on Emery seam 5 feet thick about three quarters of a mile from the Caledonia colliery.

Beside the above mentioned workings, the Dominion Coal Company has erected a coal washing plant on the Sydney and Louisburg railway about three miles from Morien junction. The operation of coal washing removes 41 per cent of the contained ash and 28 per cent of the sulphur. Water for the coal washers is obtained by gravitation from Morrison lake.

Inverness Coal Field.

This comprises a series of narrow areas on a line extending from Judique to Margaree on the western shore of Cape Breton Island in the county of Inverness. These areas of productive measures form parts of the rim of a basin the greater portion of which has been removed by erosion. Seams of coal of workable size have been found at Port Hood, Mabou, Inverness or Broad Cove and Chimney Corner.

COAL.
Nova Scotia.

At Port Hood the strata run parallel to the shore for about two miles. One seam about 7 feet thick is worked. Considerable work on this seam was done thirty five years ago, but the mine was closed in 1878 and resumed on a large scale in 1899.

At Mabou a small coal field shows several seams of good thickness which outcrop there. At Inverness or Broad Cove, north of Cape Mabou is a coal area in which outcrop several seams ranging in thickness from two to twelve feet. The dip is seaward at an angle of about twelve degrees. At Chimney Corner Mines other workable seams occur.

Work on some of these coal areas was carried on as far back as 1866, and in some places the operations were on a large scale, but subsequently very little development was done until three years ago. A great drawback to the development of these areas, was the lack of shipping facilities; the coast does not offer suitable harbours. In 1900 however, a line of railway was completed from Inverness or Broad Cove to Port Hastings, and was subsequently continued to Point Tupper on the Intercolonial. This gives the field a connection with the railway system of the continent; operations on a large scale have been resumed. There are at present three companies at work.

Inverness Railway and Coal Company, Limited.--This company, formerly called the Inverness and Richmond Railway Company, owns coal areas at Inverness or Broad Cove, Port Hood, Chimney Corner and Margaree Island. Its most extensive operations are at Inverness on a seven foot seam, with a dip of one in seven. The company has a shipping pier at Port Hastings.

Coal produced in 1902, 42,934 tons.

Port Hood Coal Company.—This company incorporated in 1899, operates a colliery at Port Hood on a seven foot seam. Worked by a slope 1,150 feet.

Persons employed in 1902, 92.

Coal produced 38,659 tons.

Mabou Coal Company.—Operates at Mabou where work, mostly of a development nature, is proceeding on three seams, 7, 8 and 13 feet respectively.

A railway about 6 miles long is projected, connecting the mine with a shipping place at Mabou Harbour.

Richmond Field.

COAL.

In the south-western portion of Richmond county, coal occurs in several localities. Nova Scotia.

Extensive explorations have been carried on in this field, and coal has been discovered at Coal Brook, Caribacou, Little River and Sea Coal Bay. Although comparatively large sums were spent between 1863 and 1878, also in 1900 and 1902 on exploration work, very little systematic mining has been done.

Coal Brook.—At this place some exploration and drilling were done in 1902. A bore hole was put down to a depth of 520 feet on the north bank of Coal Brook, near the proved outcrop of a seam. The drill was then moved 800 feet to the west, down stream, and a second boring struck coal 1 foot 8 inches at a depth of 170 feet. The hole was continued to 1,020 feet but did not strike any other seam of importance. The details of the boring are given in the report of the Department of Mines of Nova Scotia for 1902, and in the Summary of the Geological Survey for the year 1902.

Sea Coal Bay.—Here a seam of a thickness of about 11 feet gave, on analysis, such a large proportion of ash as to make it of very little use for ordinary purposes.

In his report on this coal field, Mr. Hugh Fletcher, of the Geological Survey, gives a summary of his own observations and of information gathered from various sources. Rep. of Progress, Geol. Survey, 1879-1880.

Pictou Coal Field.

This field situated almost in the centre of Pictou county, has an area of about 25 square miles. It is 11 miles long, with a maximum width of 3 miles between New Glasgow on the north and Stellarton on the south. The field is therefore small, but the seams are of great size, two being nearly forty feet in thickness.

The district is of a remarkably intricate structure, being cut up by numerous faults of various magnitude, and the productive measures are almost completely surrounded by a girdle of faults. The field is very well situated for railway communication, which advantage, however, is somewhat offset by the physical difficulties encountered due to faulting. It has also been noticed that the seams change to a remarkable degree within short distances. The field was opened in 1798, but the first systematic work was contemporary with the development of

COAL.

Nova Scotia.

the Cape Breton field in 1827, when both became the property of the General Mining Association.

The Pictou field is conveniently divided into three districts, viz.:—the Central or Albion, the Western or Westville, and the Eastern or Vale.

In the Albion, four seams have been worked. They are the Main, 38 feet thick, the Deep, 22 to 38 feet, the Third, 10 to 13 feet, and the McGregor, 13 to 20 feet. The measures containing these seams rest conformably on the Millstone Grit. The dip of the coal-bearing measures varies from the horizontal to over 30 degrees. Several other seams have been reported in this section, but none of workable size.

The Westville section is separated from the Albion section by a downthrow fault, estimated at 2,600 feet. The seams of this section are believed to be equivalent to those of the Albion section. The variation in dip and change of character in short distances are similar in both sections.

The Vale section is in the form of a syncline with east-and-west axes. The thicker and more valuable seams appear in the southern outcrop, where they are worked. Two seams of this section, viz., the McBean and the Six Foot have been extensively worked.

The collieries in operation in the Pictou field are as follows:—

Acadia Colliery.—Operated by the Acadia Coal Company. It is situated at Westville, three miles from Stellarton.

Seam worked 10 feet, dip 27°.

Opened by main slope over 4,000 feet.

Safety lamps used exclusively.

Albion Colliery.—Operated by the Acadia Coal Company. Situated at Stellarton on the Intercolonial Railway. This important colliery taps four seams, by shafts and long slopes. Work is now carried on on the Third seam 10 to 13 feet, Deep seam over 20 feet, and McGregor 13 to 20 feet.

Safety lamps are used in this colliery.

Vale Colliery.—Operated by the Acadia Coal Company. This colliery is on a six foot seam which is worked on both slopes of a basin; the dip has an average of 15°. Slope 2,800 feet. This mine was worked with open lights until a couple of years ago, when the management as a measure of precaution, introduced the use of safety lamps.

The Acadia Coal Company in 1902, produced from the three collieries which it controls about 324,800 tons of coal, giving employment to 835 persons. COAL. Nova Scotia.

Drummond Colliery.—Worked by the Intercolonial Coal Mining Company. Three seams are tapped in this colliery. The Main, 17 feet; second seam 12 feet and the third seam 8½ feet. The coal produced in 1902 was nearly 231,840 tons. Persons employed 665.

Marsh Colliery.—Operated by the Nova Scotia Steel and Coal Co. This company has held this property for a number of years past, but only began actual work on it in 1901. It is situated between New Glasgow and Thorburn on the George McKay or Four Foot seam. Worked by slopes now 1,575 feet long. The coal is shipped to New Glasgow by the Vale Colliery railway and thence to Trenton by the Intercolonial railway. This colliery in 1902 produced 25,488 tons of coal, and employed 95 men.

Cumberland Field.

This is the most westerly of the coal districts of Nova Scotia, a part of it being adjacent to Chignecto Bay.

In this field there are two coal producing areas, both in Cumberland county. One situated near the coast, may be called the Joggins area, and the other situated about 15 miles to the east of the first at Springhill. The equivalence of the seams in these two basins has not yet been determined. These two coal-bearing areas are separated by a development of Permian strata, and this intervening space is affected by several faults. The coal measures of the Joggins area form a narrow strip some eighteen miles long.

In the Joggins area the following seams of workable size are known: At Joggins two seams, respectively 4 and 6 feet; at River Hebert one 5 foot seam with two shale partings; at Maccan two seams, the upper 2½ and lower 4½ feet; at Chignecto, a seam 9½ feet, of which 2½ feet are shale partings; at the Styles mine a seam 7 feet 8 inches with a S.W. dip of 40°.

At Springhill three seams are at present worked; in Mr. Scott Barlow's reports these three seams are called in descending order: the North or Thirteen foot seam, the East seam, and the West eleven foot, or Black seam. By courtesy of Mr. J. R. Cowans, the General Manager of the Springhill Collieries, which are operated by the Cumberland Railway and Coal Co. the following section was furnished to the Mines

COAL. Nova Scotia.

Section of the Geological Survey, through Mr. Hugh Fletcher. The section gives the stratigraphical succession at the Springhill mines as revealed by the mine workings. Mr. Fletcher gives the following information in regard to it:—

"This section is original. . . The upper portion is compiled from a horizontal tunnel 502 feet long, between No. 3 and No. 1 seams and another 250 feet long between No. 1 and No. 2. The remainder is from a tunnel cut across the strata underlying No. 2 seam for 1,122 feet, from the 2,600 ft. level of No. 2. The dip varies from 30° to 38°."

Section of Coal Measures at Springhill mines, N.S., in descending order.

		Feet.	Inches.
1	Coal, north or No. 3 seam	9	0
2	Strata	238	0
3	Coal, East or No. 1 seam	10	0
4	Strata	118	0
5	Coal, West or No. 2 seam	10	0
6	Strata	45	5
7	Coal 0′ 1″; Stone 0′ 8″; Coal 2′ 0″; Stone 0′ 2″; Coal 0′ 3″	3	2
8	Strata	44	6
9	Coal 0′ 9″; Stone 0′ 3″; Coal 1′ 10″	2	10
10	Strata	5	4
11	Coal	0	11
12	Strata	85	10
13	Coal	2	2
14	Strata	29	2
15	Coaly shale	0	2
16	Strata	37	7
17	Coaly shale	0	2
18	Strata	7	8
19	Coal	2	1
20	Strata	27	11
21	Coal	1	7
22	Strata	39	4
23	Coaly shale and coal	0	6
24	Strata	25	5
25	Coal	0	6
26	Strata	42	4
27	Coal 0′ 11″; Stone 0′ 3″; Coal 1′ 5″	2	7
28	Strata	10	7

COAL.
Nova Scotia.

29	Coal 0′ 3″ Stone 0′ 7″ Coal 2′ 0″	2	10
30	Strata	11	4
31	Coal	0	4
32	Strata	3	10
33	Coal	0	3
34	Strata	20	1
35	Coal	1	0
36	Strata	11	2
37	Coal and coaly shale and stone	1	1
38	Strata	8	10
39	Coal	0	4
40	Strata	28	5
41	Coal 0′ 3″ Stone 0′ 2″ Coal 0′ 6″	0	11
42	Strata	25	0
43	Coal 0′ 0½″ Stone 1′ 7″ Coal 0′ 1″ Coaly shale 0′ 5″	2	1½
44	Strata	35	0
45	Coaly shale 0′ 2″ Coal 0′ 2″ Coaly shale 0′ 2″ Coal 2′ 6″	3	0
46	Strata to face of tunnel	5	8
	Total thickness	963	11½

Joggins Mines—Operated by the Canada Coal and Railway Company. This colliery is situated one mile from the shore of Chignecto Bay. It is connected with the Joggins wharf by a tramway. The nearest railway station is Maccan on the Intercolonial, distant eleven miles, with which it is connected by a standard gauge road.

Seam worked 4 to 5½ feet thick, dip 17°, on which are two slopes, 2,500 and 2,700 feet; only one of these is at present in operation. Underground haulage by tailrope system. Coal produced in 1902, 64,960 tons, giving employment to 276 persons. Besides this comparatively large producing colliery, there are scattered throughout this area, smaller mines operated. In 1902 there are records of four such mines having produced a certain amount of coal. These are the Chignecto Mine which produced 2,512 tons, the Strathcona, 2,352 tons, the Jubilee 1,543, the Scotia about 500 tons; besides these there are others which have been opened and worked for some time.

COAL.
Nova Scotia.

Springhill Collieries.—Worked by the Cumberland Railway and Coal Co. On three seams 10 feet wide, dip 30°.—Worked by slopes. This colliery is connected with the Intercolonial Railway by a railway 5 miles long, and by an extension 25 miles long with Parrsboro' on the Bay of Fundy, from where shipments by vessels are made.

This colliery, the most important of the Cumberland field, is well equipped and the surface plant is very complete.—The coal is specially well adapted for steam purposes, and the produce of the mine is largely used by the Intercolonial, Canadian Pacific and Grand Trunk Rail ways.

New Brunswick.

Coal produced in 1902, 538,720 tons. Men employed 1,537.

NEW BRUNSWICK.

Discovery of coal in the Province of New Brunswick. dates back to 1782.—The most important, and so far, only field of economic value in this province being that situated at the head of Grand Lake, Queens county. This deposit has been worked to a limited extent since 1825. Rocks of Carboniferous age have been recognized over a great part of New Brunswick, but according to the conclusions arrived at by investigation and studies the coal seams occurring in them do not belong to the productive measures corresponding to those of Nova Scotia and the conditions under which the known coal occurs in New Brunswick are not very favourable for mining on a large scale. Hopes were entertained that south of the Coastal Range the features more closely resembled those of the Nova Scotia coal basins. Deep borings were undertaken at different places, but results obtained do not seem to be encouraging, for no workable coal seams were encountered. Therefore the coal bearing measures of the province are limited to the Grand Lake Field. The area of this field seems to be about 100 square miles. The quality of the coal is excellent but the seams are thin, from 15 to 20 inches. The total quantity of coal in this district has been estimated at from 100 to 150 million tons.

Although mining operations were begun more than fifty years ago, they are yet conducted in a small way, and the proximity of the Nova Scotia fields, as well as the limited thickness of the seams would hardly justify the expenditure necessary for exploitation on a large scale. The beds are flat, lying with a cover varying from 2 to 30 feet, rendering it possible in many places to work them opencast. This enables small seams to be worked profitably for the local market, when the stripping does not exceed 8 feet. Beyond this depth it would be more advantageous to work under ground.

MANITOBA AND NORTH WEST TERRITORIES. COAL.

Manitoba and North-west Territories.

In Manitoba and the North West Territories the coal measures occur in the Cretaceous system or in the Laramie, which may be regarded as its upward continuation. The coal is therefore of more recent age than that of the Atlantic Coast. The quality of the fuel grades from lignite or brown coal as that found in Southwestern Manitoba, to anthracite in the Rocky Mountains. These various grades of coal are found in measures differing little in regard to geological age, but depending more on the amount of alteration and disturbance undergone by the rocks. Therefore as might be expected, the quality of the fuel improves as the Rocky Mountains are approached. The Souris river country and eastern Assiniboia yield only lignites, whereas in western Alberta the character changes to lignite coal, becoming more and more bituminous as the Foot Hills are reached and on the outer range of the Rocky Mountains, steam coal and anthracite are produced.

It is roughly estimated that the coal bearing region of the North West Territory, between the international boundary and the 56th degree of latitude, has an area of some 65,000 square miles, and although the fossil fuel of the greater part of this is lignite, which is not as valuable as the true coals, yet such deposits possess great importance as sources of supply of fuel for the adjacent farming communities.

Several separate coal-bearing districts or basins have been recognized throughout the region, and in the majority of these, some work has been done, either of a prospecting nature or for local wants, while in some places, coal seams are systematically worked and extensive well-equipped collieries are in operation.

Souris River and Turtle Mountain Fields.—The Souris district is situated in the south eastern part of Assiniboia and is underlain by several seams of lignite which constitute an almost inexhaustible supply. The use of this fuel in the districts remote from the sources of supply of better grades of coal, is extending rapidly, and the Souris lignite is now used for the generation of steam.

In the vicinity of Estevan, three seams are recognizable over a great part of the region. The upper is four feet thick and is the most constant. The middle is very variable in thickness, reaching in places a maximum of 6 feet. The lower is more strictly speaking a series of seams separated by partings of clay. The quantity of the lignite of this last seam is superior to that of the upper one.

COAL.

Manitoba and North-west Territories.

Roche Percee and Coalfields mines.—Operated by the Souris Coal Mining Co. This company owns sections 3, 4 and 5, tp. II, range VI, and sections 32, 33 and 34 tp. I, range VI. The seam worked is about 8 feet by adit on the banks of the Souris river. This mode of working presents the objection of considerable upgrade haul to reach the prairie level, and it is probable that work by shaft from the prairie level would decrease the cost of haulage. The mines are well equipped, having air compressors, coal-cutting machines, &c. They are equipped for an output 600 tons a day.

The Turtle Mountain Field is in the south western part of the province of Manitoba and is separated from the Souris field by a synclinal in which no coal has been recognized as yet. Several coal seams were found on the northern flank of Turtle Mountain, a number of years ago but so far have not given rise to very active mining operations. They are only small workings to supply local wants.

Belly River Coal Fields.

This coal-bearing region is situated in the southern part of Alberta. According to the results of Dr. Dawson's explorations in that region the outcrop of the fuels which occur on the Belly river have been traced northwestward as far as the Red Deer river and southwestward to the 49th parallel, a distance of about 150 miles. The thickness and quality of the fuels vary greatly, but on the Belly river and on the lower part of the St. Mary, a length of outcrop of 18 miles may be considered as workable. A list of the principal localities of the region, where natural outcrops of coal and lignite were observed, was published in the report of the Geological Survey for 1882-83-84, Part C.

Outcrops of coal are worked in numerous places, but in the majority of cases to supply only local demand. In Lethbridge, however, on the branch of the Canadian Pacific Railway, an important colliery is in operation.

Lethbridge Colliery.—Operated by the Alberta Railway and Coal Company. Seam worked 5½ feet, with a fire-clay parting of 2 to 6 inches. System of working, room and pillar, with coal-cutting machines and endless rope haulage. The mine is equipped for a production of 1,000 tons a day, but it is not worked to its full capacity. The company owns 66 miles of railway, from Lethbridge to Coutts, Alberta.

Cascade Basin.

COAL.

Manitoba and North-west Territories.

This is part of the Bow River valley, which is underlain by Cretaceous coal-bearing rocks. It forms a basin or trough running approximately from the northern part of the Kananaskis range, south of latitude 51°, longitude 115°, in a northwesterly direction. Its total area is some 60 square miles. This area, although small, contains much coal. The rocks here have been much disturbed; in places the seams assume an almost vertical attitude. Most of the coal is bituminous, although some of the seams have been locally converted to anthracite.

At Marsh's mine, near the south end of the field, are two seams, one about 15 feet and the other eight feet. Three miles to the north-west of this are several openings into beds of workable size. At Canmore there are three seams of 4 feet, 12 feet and 16 feet, respectively. At Anthracite three seams are now being worked, two of a thickness of 4 feet each and one of 3 feet. All of these seams are situated very near the main line of the Canadian Pacific Railway.

The measures in this field are often faulted, and the seams dip to the south-west at an inclination varying from 15 to 60 degrees. At Canmore two of the seams are almost vertical. The field was first opened by the Canadian Anthracite Coal Company in 1886 at Canmore and Anthracite.

Canmore Colliery.—This colliery is worked by the H. W. McNeil Company. Four seams worked which vary considerably in thickness from 3 to 6 feet, shaft and room and stall method. The product of the mine is a good bituminous coal.

Anthracite Colliery.—Operated by the H. W. McNeil Company. There are three seams worked which produce anthracite coal. The mine has an output of 100 tons a day. Both the Anthracite and the Canmore collieries are situated on the main line of the Canadian Pacific Railway.

In the Edmonton district there are several small mines operating, supplying the needs of the villages and market centres of that region. This industry, however, will certainly grow as the district becomes thickly settled, and may in time assume great importance.

COAL.

Manitoba and North-west Territories.

Blairmore–Frank Coal Fields.

This coal-bearing area is situated on the eastern slope of the main range of the Rocky Mountains and extends in width from Crow's Nest Lake for a distance eastward of fourteen miles. Its southern limit would be almost latitude 49° 20′ and its northern boundary has not been determined.

In this field a section of the coal measures observed at Cat Mountain gave some 740 feet in which there are present 21 seams of an aggregate thickness of 125 feet 3 inches. Until 1900 very little work had been done in this field, but within the last three years the development of this region has been very active.

Frank Colliery.—This is operated by the Canadian American Coal & Coke Company. It is located on the east flank of Turtle mountain. Seam worked nine to twelve feet, dip 83° west. Worked by a main entry run in some 4,500 feet. Output about 500 tons a day to be increased shortly. The coal produced is an excellent steam coal though high in ash.

Lille Collieries.—Operated by the United Gold Fields of British Columbia. The mine is situated on Gold Creek, three and a half miles above the town of Frank. A railway line connects it with the Crow's Nest branch of the Canadian Pacific Railway.

Recently another important colliery has been added to these two. It is operated by the International Coal and Coke Company, Blairmore, and is said to be shipping, but no particulars are at hand.

Besides these collieries, a great deal of prospecting work has been done in the region, and from all appearances this coal field will probably grow in importance and become a great factor in the question of fuel supply of the mining districts, and smelting centres of British Columbia and adjacent parts of the United States.

British Columbia.

BRITISH COLUMBIA.

In western Canada coal occurs in connection with newer rocks than in the east. Although Carboniferous rocks of great thickness are frequently met in the west, they are all marine deposits, mainly limestones. Swamps and marshes which afford the conditions giving rise to accumulation of vegetable matter, producing coal beds, existed in the Cretaceous and Tertiary times. In character the coals of British Columbia range from anthracite to lignite, showing that the grade depends on conditions of metamorphism rather than on age.

Four recognized coal-fields may be named, but mineral fuels are known in many other places, which have only to be worked in order to receive recognition. COAL. British Columbia.

The Crow's Nest Pass Field.

The Nanaimo Field.

The Comox Field.

The Queen Charlotte Islands Field.

Crow's Nest Pass Field.

This field is situated immediately west of the summit of the Rocky Mountains, which form the boundary between Alberta and the province of British Columbia. It has a length north and south of about thirty five miles and a maximum width of thirteen miles. An east and west line passing through the town of Fernie, divides it into two parts almost equal. On the west it is bounded by the Elk river, and on the east by the main ridge of the Rockies. About 230 square miles are underlain by the coal measures. Coal was discovered in this district many years ago and the first allusion to its existence in the Reports of the Geological Survey dates back to 1883, when Dr. G. M. Dawson approximately defined and examined the field in a preliminary way; however, it was only on the construction of the Crow's Nest Branch of the Canadian Pacific Railway, a few years ago, that it became important from an economic standpoint.

The coal occurs in the Cretaceous rocks; it is bituminous in character, and cokes well; some of the upper seams are said to partake of the character of cannel coal. In a section of the coal measures of the area, in a thickness of 4,700 feet, over 215 feet of coal were observed in beds of from one foot to forty six feet. Of these at least one hundred feet would be workable, and on this assumption, some 22,-600,000,000 tons would be available over the total area of 230 square miles.

There are at present three collieries in this field, working and producing actively. They are all operated by the Crow's Nest Pass Coal Co.

Coal Creek Collieries.—The Crow's Nest Pass Coal Co. was incorporated in 1897 and operates these collieries since that time. The workings are situated on Coal Creek, about five miles from its mouth. Seams worked 10 feet, 6 feet and part of a 36 foot seam. They are entered by tunnels. The mine is connected with the Canadian

COAL.

British Columbia.

Pacific Railway by a spur from the town of Fernie. At this place there are at present over 400 coke ovens of the bee-hive pattern, in operation. Production of this mine in 1902, 267,429 tons of which about one half was used in the production of coke.

Michel Colliery.—These workings are situated on the Crow's Nest branch of the Canadian Pacific Railway. Work has been done on eight seams which cutcrop here, but at present there are three mines in operation and producing while the others are being developed. There are 200 coke ovens in operation, and 200 more under construction. Production of these collieries in 1902, 117,515 tons of which 50,000 were converted into coke.

Morrissey Colliery.—Situated on Morrissey Creek, about four miles from the Canadian Pacific Railway. The colliery is connected with the Great Northern Railway by a branch from Jennings, Montana. Four mines are in operation at Morrissey, and a bank of 200 coke ovens are under construction. Production for 1902, 46,291 tons to be increased greatly in a near future.

West Kootenay, Kamloops.

In the Kamloops district of the West Kootenay, there are several occurrences of coal and lignite in rocks of Tertiary age. The most important of these known outcrops is on the Nicola river, near the Coldwater river. A list of coal outcrops in this district was given in Dr. G. M. Dawson's report on the Kamloops map sheet, Geological Survey Report, part B, vol. VII, 1894. In his report for 1901 the Provincial Mineralogist for British Columbia mentions that work is going on in this basin but detailed information is not available.

North Fork Kettle River.

The following extract from the Summary Report of the Geological Survey for 1901 is interesting as mentioning a new discovery of coal in the West Kootenay District.

"The new coal fields as they are locally called, are situated about twenty-four miles above the forks of the East Branch on the Main North Fork of the Kettle river, or about fifty-two miles from Grand Forks. Here, as above mentioned, a tertiary outlier lies on the granite. The tertiary rocks consist of tuffs, ash rocks, and a little shale overlaid by basalts and other volcanic rocks. The first exposure of coal on the west bank of the river occurs in a coarse tuff filled with

fragments of volcanic rocks, and crystals of minerals belonging to volcanic rocks. Above this tuff is a thick bed of another filled with boulders from the granite of the surrounding country. In the tuff are little lenses of carbonaceous material, the remains of plants of which the form is sometimes preserved and a thin seam (about an inch) of argillaceous material and coal. The tuffs have been somewhat squeezed. The strike is about N. 20°E, angle of dip 45°W. The extent of coal bearing rocks is not large as they are overlaid by the unproductive volcanic flows and immediately underlaid by granite which is exposed on the east bank for the greater part of the distance between the two exposures of coal. Nor have they a wide areal extension, as the granite boulders in the river and tributary creeks testify.

Colonel N. E. Linsley, of Spokane, who examined the district after my visit, reports having discovered four seams of coal on the lower (Gilpin's) claim. Of these the upper (seven inches wide) was the largest and was separated from the lowest by 150 feet of tuffs. He also found the area of coal bearing rocks to be extremely circumscribed. The coal is of very fair quality, coking easily and well.

Nanaimo Coal Field.

This field is situated on the Island of Vancouver, in the south-eastern part. Its area has been estimated at about 200 square miles. Two seams, at least, of workable thickness are known but the measures being much folded and cut up by faults, it is very difficult to correlate the beds in the various parts of the field.

The product of both this and the Comox areas is largely exported to California where it competes successfully with the coals produced in the United States although handicapped by an import duty.

Nanaimo Collieries.—Operated by the Western Fuel Company. who took over the properties of the New Vancover Coal Mining Co. This latter had been formed in 1862 and reorganized in 1889. Its output is the largest of the coal companies operating in Vancouver Island. Figures of production for 1902 are not available, but in 1901, the output amounted to 584,826 tons. The collieries consist of the following workings.

Northfield Colliery.—Situated four miles from Departure Bay. Seam worked 2 to $3\frac{1}{2}$ feet thick; dip, 6 degrees; worked by shaft 440 feet deep, and slope at bottom 2,100 feet. System of working, long-wall. This colliery is at present idle.

COAL.

British Columbia.

No. 1, Shaft, Esplanade.—Situated half a mile from the wharfs of Nanaimo harbour.

Seam worked the 'Harbour'; thickness, 5 to 12 feet; dip, 6 degrees. System of working, pillar and stall.

Haulage.—For haulage from the levels, which are in about 2 miles from the foot of the shaft, the company uses electric motors.

Ventilation by Guibal fan, 36 feet in diameter and 12 feet wide. Connected with the Protection Island shaft which is used as intake.

Lamps, naked lights.

The workings of this extensive colliery are under the waters of Nanaimo harbour and beneath the surface of Protection Island. The mine is quite safe from invasion by water, being protected by a thickness of rock and earth varying from 400 to 1,200 feet between the workings and the bed of the harbour. The pillars left in place amount to two-thirds of the original seam, this large proportion being thought necessary to insure safety. They will be robbed at a later period.

Protection Island Shaft.—Situated 300 yards from the shipping wharf and half a mile from Nanaimo.

Seams worked, the 'Douglass,' upper and lower. Thickness of upper seam 6 to 8 feet; dip 6 degrees, vertical depth of shaft to seam 670 feet. The lower seam is reached at a depth of 740 feet and is 4 feet thick.

In the upper seam two slopes have been driven, 900 and 600 yards respectively.

System of working, pillar and stall.

Ventilation.—This shaft is the intake of the system of ventilation which takes in Esplanade shaft.

Southfield Colliery.—No. 5. Situated five miles from Nanaimo in the southern part of the area controlled by the Western Fuel Co.

Seam worked varies from 6 to 12 feet in thickness. Dip 6 degrees. Vertical depth of shaft 508 feet.

System of working, pillar and stall.

This part of the field is very much cut up by faults and breaks.

Harewood Mine.—This mine is situated about three and a half miles south west of Nanaimo. This was worked actively some 25 years ago, and subsequently acquired by the New Vancouver Coal and Land Co. who left it idle for some time. In 1901 work was resumed at this place

and the mine produced for a couple of years. The main workings are the Harewood slope on a six foot seam and a shaft which are now connected. Work however, was discontinued in September 1902. COAL. British Columbia.

Wellington Colliery, Cranberry District.—Operated by the Wellington Colliery Co.—The colliery is an important producer. The workings consist of No. 1 slope, No. 3 slope, and the Tunnel. The main equipment of the colliery consists of five miles of railway, four locomotives, 350 coal cars, stationary engines, electric power house, &c. The company has wharves and bunkers at Ladysmith, Oyster Harbour. The work is carried on by pillar and stall. No figures of production are available for 1902, but in 1901 the output of the mine was 405,986 tons.

Alexandria Colliery.—This is situated in South Nanaimo District and is operated by the Wellington Colliery Co. Worked by a slope. The colliery is connected by a short railway line with the E & N railway. In 1901 the output of the mine was 68,420 tons. In 1902 no work was carried on, the colliery being allowed to remain idle all year. The Wellington Colliery Co. whose offices are at Victoria employ a staff for prospecting in this and other districts.

Comox Field.

This field is situated on the north-west of the Nanaimo field from which it is separated by the intervention of crystalline rocks. The Comox area has probably a greater extent of productive measures than the Nanaimo field. Mr. Richardson, late of the Geological Survey, estimated it at 300 square miles, without taking into consideration the seaward extension.

In a section on Brown River almost the entire thickness of the productive measures is exposed, amounting to 740 feet. In this section nine seams occur, with an aggregate thickness of 16¼ feet. At the Union mines a section of 122 feet reveals ten seams aggregating to 29½ feet, the thickest being 10 feet.

Wellington Colliery-Cumberland Town, Comox District.—This mine was formerly designated by the name of Union Mines. It is worked by the Wellington Colliery Co., who also operate two other mines in the Nanaimo field. The main workings consist of one slope and two shafts, worked partly by pillar and stall and partly by longwall. Seams worked, three feet and five feet respectively. The surface plant consists mainly of nearly 12 miles of standard gauge railway to ship-

COAL.
British Columbia.

ping wharf; 4 locomotives; steam saw mill; coal washers; 200 beehive coke ovens at the mine beside 70 at Union.

This company also carries on the manufacture of fire-bricks, from the fire-clay mined in connection with the extraction of the coal.

Queen Charlotte Island Field.

This field is in that part of the Cretaceous area of the province which extends over parts of Graham and Moresby Islands, on both sides of Skidegate Sound.

The coals are anthracite and bituminous, the former comparing favourably with that of Pennsylvania. In the 'Mineral Wealth of British Columbia' Dr. Dawson speaks of the Cowgitz seams on the Skidegate as follows:

'At Cowgitz, the Queen Charlotte Coal Mining Co. about 1871 constructed a wharf, houses, tramway, &c., and attempted to work the coal seams which have there the character of anthracite, but met with difficulties in following the seams, of which some portions were found to be in a crushed and pulverulent state.

'Though these efforts were not attended with success, the work was not carried far enough to prove that the coal in this vicinity is not of a workable character. Further exploration appears to be fully justified by what is known of the place * * * The beds containing the anthracite are almost vertical, and it is evidently on account of the disturbance and local alteration which it has suffered that the coal has passed into the condition of anthracite. The best seam found had a maximum thickness of a little over 6 feet, while a second outcrop showed 2 feet 5 inches.'

A bed 18 feet thick, of bituminous coal, has been reported on the Ya-Kum River, midway between Skidegate and the head of Masset Inlet.

Means of communication with the coast, however, must be provided before this deposit can be utilized.

In 1892 Mr. H. E. Parrish, C.E. and M.E., late of the staff of the Geological Survey at Pennsylvania examined some coal areas on this island for private parties. After mentioning and describing some prospecting work done at Camp Robertson, section 20, township 5; Camp Anthracite, section 17, township 5; Camp Wilson, section 36, township 9; he concludes with the following remarks:

COAL. British Columbia.

* "With the knowledge I have of the coal regions of Pennsylvania, acquired there as a mining engineer and on the geological staff of that state it must gratify you to know that in my judgment you have the best coal field I have seen. Until I visited it, I had no conception such a valuable field existed on the Pacific Coast. You possess a number of beds of unusual thickness, containing coals of superior quality suitable for all requirements. You have anthracite, first class steam, gas and coking coals, and a bed over 15 feet thick, excellent for domestic purposes."

Peace River region.

Of the other localities in British Columbia where coal has been observed, the country in the Peace river region is likely to come into prominence if the projects now being discussed of the building of the Grand Trunk Pacific Railway become a fact. The line as it is now projected would follow part of the Peace river valley and would pass at a not very great distance from the cañon where Dr. Selwyn and Dr. Dawson observed outcrops of coal.

Dr. Selwyn in his report on the Peace river country in 1875, mentions four seams of good lignite coal from six inches to two feet in thickness as occurring on Peace river below the cañon.

As to the coal bearing character of the country, Dr. Dawson expresses himself as follows: "It would thus appear that while in the region, lying between the Athabasca and the Peace rivers, no coal seams sufficiently thick to be of great economic value have yet been discovered- that coal and lignite of good quality occur in two distinct series of beds. Wherever natural sections of these occur in the valleys of rivers and streams, coal in greater or less quantity is found, and the persistently carboniferous character of the beds, thus abundantly proven. There can be little doubt that beds of a workable character exist in different parts of this district and will be found by further search.

The promising coal bearing belt of rocks supposed to belong to the lower sandstones and shales which run south-eastward from the canon of the Mountain of Rocks to Table Mountain and the lower forks of Pine river, probably extends still further in the same direction, crossing the head waters of the Wapiti and Smoky rivers above the points reached in my explorations, and forming the southwestern side of a synclinal in which the Upper Sandstones and shales lie. In this the coals reported by the Indians to exist on the upper parts of these rivers may occur."

* Report of H. E. Parrish, extracts of which were published in the Report of the Minister of Mines for British Columbia for 1898, p. 1163.

COAL.

British Columbia.

In support of these views, it is interesting to quote the following section measured recently by Mr. Hugh Campbell up a small creek on the Peace river cañon.*

	Ft.	In.		Ft.	In.
Blue shale	10		Shale	20	
Shale with hard bands	6		Limestone	3	
Sandstones	10		Unseen strata	50	
Gray shale	8		Fossiliferous sandstone	30	
Impure cannel coal	2		Coal	2	7
Coal, good	9		Shale	9	0
Soft blue shale	7		Coal	0	8
Measures not seen	50		Calcareous shale	12	
Limestone	10		Coal	1	4
Sandstone	9		Hard gray shale	20	
Soft shales	20		Dark shale	10	
Coal	2		Coal	2	8
Shales with bands	30		Hard rock	2	
Sandstone	10		Soft dark shale	2	6
Shale	1	3	Coal	4	2
Cannel coal	1		Soft clay	3	
Shale	20		Shale	6	
Coal	3	10	Limestone	6	
Sandstone	3		Coal	3	
Shale	4		Shale	5	
Sandstone	20		Coal	2	6
Coal	1	4	Sandstone	8	
Sandstone	10		Shale with bands	8	
Shale	5		Sandstone	6	
Sandstone	20		Shale	1	3
Limestone	4		Coal	3	
Shale	10		Band	1	
Hard bands	50		Coal	3	
Limestone	4		Dark soft shale	2	
Sandstone	15				

The measures, according to Mr. Campbell, dip S. 30° E. at an angle of about 13°.

YUKON TERRITORY.

Yukon Territory.

Lignites and lignitic coals occur in the Tertiary rocks of the valleys of the Yukon river and of the Klondike river. On Coal creek, a branch of Rock creek, a tributary of the Klondike, a seam occurs in which a tunnel some 400 feet in length has been sunk. These workings are situated about 20 miles from Dawson. The seam worked here consists of an upper part of 3 feet of hard lignite, and a lower part of 2 to 3 feet, separated by a layer of clay about one foot. Outcrops of lignite also occur on Cliff creek, whi h enters the Yukon about 55

* From a private letter communicated by Dr. H. M. Ami.

miles below Dawson. Between these two occurrences other outcrops have been observed at intermediate points, and it has been estimated that this area underlain by lignite exceeds 200 square miles.

COAL.

Yukon Territory.

On Cliff creek the lignite is worked very actively by the North American Trading and Transportation Company. The workings are situated on both banks of the creek, 1¾ miles from its mouth. The coal is shipped to Dawson for heating purposes and is also used by river steamers. The mine is connected with the shipping wharf by a narrow gauge railway.

COAL.
Analyses.

ANALYSES OF CANADIAN COALS.

SYDNEY FIELD, N.S.

Seam of Mine.	Fast or slow cooking.	Moisture.	Vol. Matter.	Fixed Carbon.	Ash.	Sulphur.	Spec. Gravity.	Theor. Evap. Power.	*Analyst.	†Reference.
		p. c.	p. c.	p. c.	p. c.	p. c.				
Hub seam	......	......	29·10	65·50	4·50	3·29	......	......	g	C
"	......	......	28·62	68·14	3·24	2·29	......	8·59	k	D
Block House seam	S	600	29·48	65·57	4·35	2·63	1·292	8·97	a	A
"	......	......	31·94	62·79	5·27	3·76	......	7·67	k	D
Harbour seam	S	·80	27·85	67·05	4·30	2·32	1·29	9·19	a	A
" Internat. Coll	......	......	34·09	62·92	2·99	2·26	......	7·76	k	B
" Glace Bay	......	......	30·21	67·78	2·01	·90	......	9·31	k	D
"	......	......	37·96	54·84	5·60	4·03	......	......	g	C
Victoria seam	S	·28	28·61	67·61	3·50	2·84	1·29	9·27	a	A
"	......	......	38·70	58·40	2·90	......	......	8·02	b	D
Sydney main	S	3·04	31·14	61·50	4·32	1·24	1·30	8·45	c	B
"	......	3·13	23·81	67·57	5·49	......	......	9·25	......	E
Sydney Colliery	S	1·26	33·84	60·79	4·12	1·71	1·312	8·33	a	A
"	......	......	32·74	61·54	5·72	3·37	......	8·49	k	B
McAulay seam, Gowrie mine	......	......	36·25	58·05	5·70	2·34	......	7·97	p	D
Gowrie Colliery	S	·50	28·13	66·01	5·36	2·71	1·31	9·05	a	A
Phelan seam, Caledonia Coll	S	·92	28·63	64·02	6·43	1·11	1·33	8·78	a	A
" "	......	......	33·00	57·37	9·63	......	......	7·88	d	B
" "	......	......	28·02	68·05	2·19	1·72	......	......	g	C
" Reserve Coll	......	......	32·00	63·93	2·95	1·33	......	......	g	C
" "	......	......	37·26	58·39	4·35	2·06	......	8·02	r	B
" "	......	1·00	36·26	......	4·35	2·47	......	......	r	B
" "	......	......	34·50	59·50	6·00	......	......	......	s	B
" "	......	·52	34·21	59·73	5·54	1·25	1·28	8·19	a	A
" Dominion No. 1 Coll	......	......	25·13	71·22	2·73	1·10	......	......	g	C

COAL. Analyses.

″ Old Bridgeport	....	....	31·81	63·86	3·09	1·33	....	....	*g*	C
″ Clyde Coll	....	....	32·82	64·33	2·85	2·17	....	7·88	*k*	D
Lingan seam	S	·75	34·61	61·39	3·25	1·35	1·29	8·42	*a*	A
″	....	....	30·03	66·90	3·07	·77	....	9·07	*c*	D
South Head seam	S	1·77	28·00	62·26	7·97	2·64	1·38	8·53	*a*	A
Emery seam	S	·65	32·21	63·49	3·65	2·41	1·29	8·70	*a*	A
Ross seam, Schooner Pond	....	....	38·10	58·46	3·44	1.21	....	8·03	*r*	B
Collins seam	S	1·98	26·16	66·48	5·40	2·25	1·311	9·10	*a*	A
Gardiner seam	S	....	31·96	65·22	2·82	1·18	....	....	*k*	B
″	....	....	34·33	61·97	3·70	....	....	8·51	*b*	D
Lorway seam	....	....	34·84	55·98	13·28	6·27	....	8·02	*k*	D
Tracey seam	....	2·23	30·09	66·61	·98	....	....	....	....	B
Fraser seam	....	....	31·40	62·40	6·20	....	....	....	....	B
Carroll seam	....	....	32·80	61·40	5·80	....	....	....	....	B
Block House seam	....	....	38·80	55·80	5·40	....	....	7·67	*d*	B
INVERNESS FIELD, N.S.										
Chimney Corner	F	8·19	26·39	57·70	7·72	....	....	....	....	A
Broad Cove, 7-foot seam	S	4·02	20·17	70·41	5·40	....	....	....	*c*	A
″	S	7·24	25·75	56·86	10·15	1·41	....	7·61	*t*	A
″ 5-foot seam	S	7·78	27·67	52·87	11·68	....	....	....	*a*	E
″ 4 ″	S	8·45	28·36	56·94	6·25	....	....	....	....	E
Port Hood	S	2·54	29·82	61·93	5·73	5·54	....	8·49	....	A
″ 7 foot seam	S	4·02	34·86	53·60	7·52	....	....	....	*a*	E
Port Hood mines, face of slope depth of 1,150 feet,	....	2·11	38·36	49·25	9 78	....	....	....	....	B
″ ″ face south level	....	2·47	38·48	50·39	8·66	....	....	....	....	B
″ ″ face north ″	....	2·42	37·18	50·96	9·44	....	....	....	....	B

†REFERENCES.

A. Mines and Minerals of Nova Scotia. E. Gilpin.
B. Geological Survey of Canada, Annual Reports.
C. Mining Manual. B. T. A. Bell.
D. Transactions American Inst. Min. Eng.
E. Nova Scotia Institute of Science.
F. Nova Scotia Steel Co.
G. Report of the Minister of Mines of British Columbia, 1902.

*ANALYSTS.

a Gilpin, E.
b Dawson, J. W.
c How, H.
d Brown, R.
f Hartley, E.
g Mason, F. H.
k Harrington, B. J.
l N. Y, Gas Co.
m N. S. Steel Co.
p Richard and Buist.
q Poole, H.
r Royal School of Mines.
s Manhattan Gas Co.
t Geological Survey of Canada Laboratory.
u British Columbia Assay Office.

COAL.
Analyses.

ANALYSES OF CANADIAN COALS—*Continued.*

RICHMOND FIELD, N.S.

Seam or Mine.	Fast or slow coking.	Moisture.	Vol. Matter.	Fixed Carbon.	Ash.	Sulphur.	Spec. Grav.	Theor. Evap. Power.	*Analyst.	†Reference.
		p.c.	p.c.	p.c.	p.c.	p.c.				
Sea Coal Bay, 11-foot seam	......	......	25·20	44·70	30·10	......	......	......	*b*	A
Little River, 4-foot seam	......	......	30·25	56·40	13·25	......	......	......	*b*	A

PICTOU FIELD, N.S.

Seam or Mine.	Fast or slow coking.	Moisture.	Vol. Matter.	Fixed Carbon.	Ash.	Sulphur.	Spec. Grav.	Theor. Evap. Power.	*Analyst.	†Reference.
Main seam, average of 31 analyses*	S	......	23·65	62·61	13·61	......	......	......	*b*	B
" Ford pit	......	1·48	24·28	66·50	7·74	·55	1·294	9·13	*c*	B
Albion Mines	S	1·05	26·19	63·41	9·35	1·48	1·31	8·68	*a*	A
Acadia Coal Co.—McGregor pit, slack	S	1·50	28·80	58·00	13·70	1·73	......	......	*m*	F
" " Ford pit	......	1·50	25·90	54·30	18·30	·73	......	......	*m*	F
Acadia Colliery	S	2·10	32·27	57·57	7·55	·51	1·320	......	*d*	B
Drummond Colliery—Top coal	......	·72	29·93	60·35	9·46	·26	1·309	8·29	*d*	B
" " Fall coal	......	1·56	31·69	60·32	7·56	·43	1·328	8·29	*d*	B
" " 1st bench	......	1·80	33·53	55·39	10·50	·58	1·327	7·61	*d*	B
" " 2nd "	......	1·31	29·97	60·31	8·67	1·05	1·343	8·29	*d*	B
" " 3rd "	......	1·43	30·76	59·89	8·79	·564	1·335	8·27	*d*	B
" " Coarse bench	......	1·58	32·81	37·16	31·03	......	1·765	......	*d*	B
Deep seam	S	·75	20·34	68·50	10·41	·945	1·380	9·39	*a*	A
"	S	1·30	25·44	61·65	10·25	·861	1·330	......	*d*	B
"	......	2·54	20·46	68·50	8·50	1·69	1·345	9·41	*c*	B
McGregor seam	......	......	22·50	65·70	11·80	......	1·334	9·03	......	B
"	......	......	23·30	70·00	6·70	......	1·301	9·62	......	B

COAL.
Analyses.

Intercolonial Mine	S	1·52	29·46	60·19	9·10	1·625	1·330	8·24	a	A
Montreal and Pictou Mines		4·40	24·95	61·07	9·58			8·39	c	B
" " "		5·47	19·93	68·55	6·05		1·360	9·41	c	B
McBean seam, east side of East River		1·57	29·29	52·36	16·76				f	B
"		2·67	28·65	49·66	19·42				f	B
"		2·67	27·20	54·86	15·27				f	B
"		1·94	23·95	57·17	16·94				f	B
"	S	·86	20·95	64·95	13·24	·85		8·90	a	A
McKay seam, north part	S	1·62	22·86	68·18	7·34	·53		9·35	a	A
" south "		·90	22·50	65·28	11.32	1·72		8·97	a	A
"		None.	29·72	62·28	8·00					B
"		None.	29·98	62·15	7·87					B
Richardson seam		·76	38·84	55·81	5·09					B
Greener	S	1·22	22·96	65·61	10·21	Trace.		8·99	a	A
Pottery		.57	19.24	72·76	7·43	·65		9·97	a	A

CUMBERLAND FIELD, N.S.

Joggins	S	2·50	36·30	56·00	5·00				a	A
Maccan	S		37·00	59·17	3·83				a	A
Styles	S	4·05	33·72	55·83	6·40				a	A
"	S	3·72	33·24	52·15	10·89				a	A
Springhill—Main seam, 11 feet—										
Band No. 1	S	·98	30·84	60·73	7·45	·85	1.31	8·33	a	A
" No. 2	S	·76	32·22	60·91	6·11	·56	1·30	8·40	a	A
" No. 3	S	1·21	33·81	63·13	1·85	·79	1·28	8·65	a	A
" No. 4	S	·30	29·19	67·95	2·56	1·21	1·27	9·28	a	A
" No. 5	S	.63	28·90	65·16	5·31	1·85	1·29	8·92	a	A
" No. 6	S	·90	34·56	60·59	3·95	·89	1·28	8·32	a	A
" No. 7	S	1·34	33·64	59·86	5·16	1·40	1·29	8·20	a	A
" No. 8	S	·56	30·27	60·89	8·28	2·65	1·33	8·35	a	A
" No. 9	S	·41	28·54	63·63	7·42	2·25	1·32	8·99	a	A

*Average of samples take every foot across the section of the seam.

COAL.
Analyses.

ANALYSES OF CANADIAN COALS—*Continued.*

NORTH-WEST TERRITORIES.

Locality.	Fast or slow coking.	Moisture.	Vol. Matter.	Fixed Carbon.	Ash.	Sulphur.	Spec. Gravity.	Theor. Evap. Power.	*Analyst.	†Reference.
LIGNITES.		p. c.	p. c.	p. c.	p. c.	p. c.				
Souris River, 7 miles from Roche Percée, seam 6 feet	......	17·78	29·51	44·36	8·35	......	......	......	......	......
La Roche Percée, seam 5 feet	S	21·84	32·15	41.61	4·40	......	1·417	......	t	B
South Saskatchewan, 10 miles above Medicine Hat, seam 4 feet	S	16·82	29·54	46·34	7·30	......	1·397	9·57	t	B
" " "	S	17·70	28·63	49·83	3·84	......	1·372	......	t	B
South Saskatchewan, 7 miles from Medicine Hat	......	19·90	30·88	44·03	5·19	......	......	......	t	B
North Saskatchewan, 40 miles below confluence of Brazeau river, seam 18 to 20 feet	S	14·78	28·46	58·69	6·07	......	1·434	9·84	t	B
North Saskatchewan, below Fort Edmonton, seam 6 feet.	S	12·89	32·19	52·17	2·75	......	1·426	9 69	t	B
" 1½ miles below ferry at Edmonton, Alta., seam 4 feet	......	11·47	36·12	48·57	3·84	......	......	......	......	......
Red Deer river, mouth of Arrowood, 6-foot seam	S	13·08	31·49	51·35	4·08	......	1·403	9·95	t	B
" 2 miles below Arrowood, 5 feet	S	14·20	30·92	51·21	3·67	......	1·393	......	t	B
" 7 miles above Hunter's Hill, 3½ feet	S	13·06	29·41	48·51	9·02	......	1·426	9·36	t	B
" 9 " " 1½ "	S	13·63	31·31	41·81	13·25	......	......	......	t	B
" 13 " " 1¼ "	S	12·62	32·08	46·72	8·58	......	1·422	......	t	B
" Tp. 38, R. 24, W. 4th M., seam 10 feet	......	7·66	25·90	34·53	31·91	......	......	......	t	B
Bow river, Grassy island, seam 4½ feet	S	11·90	31·20	50·97	5·93	......	1·416	10·19	t	B
" Blackfoot crossing, 3 feet	S	11·91	30·04	54·78	3·27	......	1·397	10·29	t	B
" 4 miles below Blackfoot crossing	S	10·72	29·26	46·09	13 93	......	......	......	t	B
" Crowfoot creek, seam 6 feet	S	11·25	31·98	50·85	5·92	......	......	......	t	B
" Horseshoe Bend, seam 4½ feet	S	11·13	36·52	43·16	9·19	......	......	......	t	B
Crowfoot creek, 5 miles from Bow river, Sec. 7, Tp. 22, Range 20, west of 4th M., 9 feet	F	10·35	30·97	43·04	15·64	......	......	......	t	B

COAL.
Analyses.

Belly river, 5 miles below Little Bow river	S	9·18	30·66	53·31	6·85	....	1·398	10·84	t	B
" coal banks, seam 5½	S	6·50	31·59	54·36	7·55	....	1·359	11·51	t	B
St. Mary river, 7 miles above junction with Belly river	S	7·02	29·41	57·28	6·29	....	1·369	11·72	t	B
Yukon District, 7 miles up Coal creek, seam 12½ feet	F	7·24	41·45	48·91	2·40	....	....	....	t	B
COALS.										
Cascade river, 2⅜ miles from confluence with Bow river, seam 20 inches	S	2·07	15·84	74·35	7·74	....	....	....	t	B
Cascade river, semi-anthracite, seam 3 feet 10 inches, ¼ mile from C.P.R.	F	1·04	9·15	87·18	2·63	....	....	....	t	B
Bow river, Coal creek seam 4½ feet	S	4·93	27·22	52·54	15·31	....	1·400	10·93	t	B
Bow river Pass seam 4 feet	S	·71	10·58	81·14	7·57	....	1·427	14·62	t	B
Coal creek, Bow river, Sec. 22, Tp. 27, R. 5, west of 5th M.	F	2·79	36·90	53·40	6·91	....	....	....	t	B
Marsh's Mine, ½ mile south of Bow river at Gap siding, 2 seams, 10 and 12 feet	....	·70	11·03	79·78	8·49	....	....	....	t	B
Little Red Deer river, 11-foot seam; foot-hills at base of main limestone range of Rocky mountains	F	1·87	13·74	79·55	4·84	....	....	....	t	B
Little Red Deer river, seam 4 feet	F	1·52	11·65	81·16	5·67	....	....	....	t	B
Sheep creek, Sec. 2, Tp. 20, R. 3, west of 5th M., 4-foot seam	F	3·08	39·37	54·50	3·05	....	....	....	t	B
Near Moose mountain, Sec. 8, Tp. 23, R. 6, west of 5th M., seam 5 feet	F	2·74	18·62	75·52	3·12	....	....	....	t	B
Head waters of Mill and Pincher creeks, Sec. 10, Tp. 5, R. 1, west of 5th M., seam 8 feet	....	1·99	20·88	61·87	15·26	....	....	....	t	B
Old Man river, north fork, 5 feet	S	1·75	16·85	61·54	19·86	....	1·530	11.32	t	B
" middle fork, 3 feet	S	3·27	26·41	50·50	19·82	....	1·432	11·13	t	B
" " 3 "	S	2·36	32·07	56·37	9·20	....	1·311	13·06	t	B
" south fork 9¾ "	F	1·93	23·23	57·50	17·34	....	....	....	t	B
Anthracite, Alberta Territory, H. W. McNeil & Co.—										
1st vein, raw	....	·10	13·09	78·94	7·87	....	....	....	....	F
" washed	....	·39	14·82	79·98	4·84	....	....	....	....	F
2nd vein, raw	....	·42	15·46	75·07	9·05	....	....	....	....	F
" washed	....	·40	6·02	89·40	4·18	....	....	....	....	F
3rd vein, raw	....	·08	15·12	76·67	8·13	....	....	....	....	F
" washed	....	·07	15·30	79·46	5·17	....	....	....	....	F

*† See page 18 s.

Coal.
Analyses.

ANALYSES OF CANADIAN COALS—*Continued.*

CROW'S NEST PASS, B.C.

Seam or Mine.	Fast or slow coking.	Moisture.	Vol. Matter.	Fixed Carbon.	Ash.	Sulphur.	Spec. Gravity.	Theor. Evap. Power.	*Analyst.	†Reference.
		p. c.	p. c.	p. c.	p. c.	p. c.				
Marten creek—Peter seam, 14 ft.	S	1·79	25·45	69·14	3·62	·51	1·305	14·99	*t*	B
" Jubilee seam, 30 ft.	S	1·89	24·88	68·86	4·37	·48	1·309	14.64	*t*	B
" Four seams, 3, 4, 5 and 6 ft.	S	2·10	44·41	43·63	9·86	....	....	....	*t*	B
" Two-foot seam	F	2·12	26·92	43·48	27·48	....	....	....	*t*	B
" Middle seam, 2½ ft	F	1·82	24·55	51·22	22·41	....	....	....	*t*	B
On Elk river seam, 15 feet	....	....	21·76	68·20	10·04	....	....	....	*t*	B
Morrissey mine, No. 1—Highest seam worked; 18 ft. thick; dip, N. 21°; strike, E and W; suitable for steam.	....	·9	22·19	70·99	5·6	....	·32	14·346	*u*	G
Morrissey mine.—No. 2—Seam, 18 ft.; dip and strike same as above; suitable for steam and household.	....	·82	11·78	71·5	15·75	·2	....	12·858	*u*	G
Coal creek mine, No. 1—Seam, 8 ft.; dip, E. 15°; suitable for steam and household.	....	·84	22·38	73·17	3·15	·46	....	14·935	*u*	G
" No. 1—Seam, 9 ft.; dip, E. 15°; steam and household	....	·92	18·85	64·42	15·65	·16	....	13·757	*u*	G
" No. 2—Seam, 6 ft.; dip, E. 15°; suitable for steam and household	....	·84	22·38	73·17	3·15	·46	....	14·935	*u*	G
" No. 3—Same seam as above; samples taken one mile apart	....	·92	20·63	72·05	6·0	·4	....	14·284	*u*	G
" No. 4—750 ft. below No. 1; seam, 22 ft.; dip, E.; 10°	....	·96	13·46	61·92	23·5	·16	....	12·114	*u*	G
Michel Mine, No. 3—Highest seam worked, 15 to 30 ft.; used for steam and coke	....	1·0	20·57	72·00	6·15	·28	....	14·656	*u*	G
" No. 4—80 feet below No. 3; 10 to 30 ft.; used for steam and coke	....	1·0	18·93	70·13	9·5	·44	....	13·850	*u*	G

COAL. Analyses.

NICOLA VALLEY.

Nicola river, mouth of Coldwater river		2·13	27·99	59·66	10·22				u	
Coal gully, Iron mountain		3·35	26·55	·59·30	10·30				u	

NANAIMO FIELD, B.C.

Wellington mines, Nanaimo		2·75	30·95	59·72	6·58				t	B
Upper seam, Nanaimo	S	38·40		51·45	10·15				t	B
Newcastle island, Nanaimo	S	1·57	30·95	58·03	8·63	0·82			t	B
" "		35·49		52·57	11·94				t	B
Esplanade, No. 1 shaft, upper seam		1·88	33·27	54·67	9·4	·78		12·672	u	G
" " lower seam		2·86	35·84	54·79	5·5	1·01		12·951	u	G
Harewood mine		1·58	33·84	52·17	11·85	·56		12·238	u	G
Southfield mine, No. 5		2·08	35·78	56·26	5·6	·28		13·261	u	G
Extension seam, bottom vein		1·28	35·26	55·83	7·30	·33		13·199	u	G
" top vein		1·24	36·49	53·72	8·20	·35		13·261	u	G
Tunnel vein, bottom seam		1·52	35·27	57·04	5·85	·32		13·416	u	G
" "		1·44	31·40	46·18	20·65	·33		11·401	u	G

COMOX FIELD, B.C.

Union Colliery		1·34	28.11	67·72	2·83				t	B
"		1·70	27·17	68·27	2·86				t	B
Baynes sound mine		1·18	34 13	48·51	16·18				t	B
Trent river	S	·97	25·09	66·42	5·95	1·57			t	B
Beaufort mine, Comox	S	29·30		55·75	14·95				t	B
Union No. 5 Pit upper seam		1·08	29·24	57·03	9·60	3·05		13·261	u	G
Hamilton lake		1·70	22·82	47·72	27·00	·76		10·626	u	G
No. 4 Slope Comox or lower seam		·88	27·34	61·82	8·70	1·26		13·881	u	G
No. 5 Pit " " "		1·32	27·62	63·64	6·70	·72		14·191	u	G
No. 6 Pit " " "		1·26	27·33	63·49	6·80	1·12		14·191	u	G

COAL.
Analyses.

ANALYSES OF CANADIAN COALS—*Concluded.*

QUEEN CHARLOTTE ISLANDS, B.C.

Seam or mine.	Fast or slow coking.	Moisture.	Vol. Matter.	Fixed Carbon.	Ash.	Sulphur.	Spec. Gravity.	Theor. Evap. Power.	*Analyst.	†Reference.
		p. c.	p. c.	p. c.	p. c.	p. c.				
Cowgitz (anthracite coal)	F	1·60	6·55	83·09	8·76	....	....	....	t	B
" Hooper creek, Skidegate Channel	F	1·99	7·65	80·62	9·74	....	1·503	....	t	B
Camp Anthracite, Sec. 17, Tp. 5	F	1·52	8·69	80·07	9·72	....	....	....	t	B
" "	F	2·85	7·59	68·25	21 31	....	....	....	t	B
Camp Robertson, Sec. 20, Tp. 5, Graham island, 6½ miles west of Skidegate inlet	F	·80	23·27	51·39	24·54	....	....	....	t	B
Camp Wilson, Sec. 36 Tp. 9	F	1·06	43·48	46·01	9·45	....	....	....	t	B
Yakoun river	S	2·65	30·59	61·33	5·43	....	....	....	t	B

YUKON TERRITORY.

Seam or mine.	Fast or slow coking.	Moisture.	Vol. Matter.	Fixed Carbon.	Ash.	Sulphur.	Spec. Gravity.	Theor. Evap. Power.	*Analyst.	†Reference.
						Coke %				
Coal creek, or east branch of Rock creek, Klondike river	F	18·31	34·96	40.88	5·85	46·73	....	....	t	B
" " " "	F	19·37	33·85	37·45	9·33	46·78	....	....	t	B
Cliff creek, tributary of Yukon	F	8·57	42·04	45·77	3·62	49·39	....	....	t	B
" " " "	F	10·58	40·10	46·74	2·58	49·32	....	....	t	B
Lewes river, six miles above Rink rapid	F	6·42	36.98	46·03	10·57	56·60	....	....	t	B
Ten miles west of Drydale station on White Pass and Yukon Ry	F	2·31	5·59	67·20	24·90	92·10	....	....	t	B
White Horse Coal Co, in tunnel 63 feet	....	1·76	5·69	68·59	23·96	....	....	....	t	
" " " top of mountain	....	3·83	15·84	47·81	32·52	....	....	....	t	

COAL.

BIBLIOGRAPHY.

Bibliography.

COAL IN CANADA.

Nova Scotia and New Brunswick.

BAILEY, L. W. & POOLE, H. S.—Reports upon the Carboniferous system of New Brunswick. Geol. Surv. of Canada.

BARLOW, S.—Report of Progress in Surveys in coalfields of Cumberland county, Geol. Surv. 1875-76.

BARLOW, S.—Report on Springhill coalfields. Report of Progress of Geol. Surv 1873-74.

BELL, B. T. A.—Canadian Mining Manual, Ottawa, 1903.

BROWN, RICHARD.—Coal fields and coal trade of the Island of Cape Breton. Reprint by Maritime Mining Record office, Stellarton, N.S. 1899.

ELLS, R. W.—On geological formations of Eastern Albert and Westmoreland counties, N.S., and of portions of Cumberland and Colchester counties, N.S. Rep. Geol. Surv. 1885 Part E.

FLETCHER, HUGH.—Report on the geology of part of the counties of Victoria, Cape Breton and Richmond, Nova Scotia. Report of Progress Geol. Surv 1876-77.

FLETCHER, HUGH.—Report on the geology of portions of the counties of Victoria, Cape Breton and Richmond, Nova Scotia. Report of Progress Geol. Surv. 1876-77.

FLETCHER, HUGH.—Descriptive notes on the Sydney coal fields, Geological Survey, 1900.

GILPIN, EDWIN.—Minerals of Nova Scotia, Halifax, 1901.

GILPIN, E. G.—Annual Reports of the Department of Mines, Nova Scotia, Halifax, N.S.

HARTLEY, E.—Notes on coal from Springhill coal field. Report of Progress, Geol. Surv., 1866-69.

HARTLEY, E.—Coals and iron ores of Nova Scotia. Geological Survey, 1870.

HARTLEY, E.—Report on Pictou coal and iron ores. Report of Progress, 1866-69.

LOGAN, SIR W. E.—Report on part of Pictou coal fields. Report of Progress, Geol. Surv., 1866-69.

McOUAT, W.—Report on a portion of the coal fields of Cumberland county. Report of Progress, Geol. Surv. 1873-74.

ROBB, CHAS.—Report on explorations and surveys in Cape Breton, Nova Scotia. Report of Progress, Geol. Surv., 1873-74.

ROBB, CHAS.—Report on the coal mines of Cape Breton county, Nova Scotia. Report of Progress, Geol. Surv., 1872-73.

COAL.
Bibliography.

ROBB, CHAS. Supplemental Report on coal mines of Cape Breton county. Report of Progress, Geological Survey, 1873-74.

RUTHERFORD, JOHN.—The coal-fields of Nova Scotia. Trans. North of England Inst. of Minining Engineers, Vol. 19, 1869-70.

British Columbia, Manitoba and North-West Territories.

BROCK, R. W.—Coal bearing rocks of Kettle Valley, B.C. Summary Report, Geol. Surv., 1900.

DAWSON, G. M.—Report on the Tertiary lignite formation in the vicinity of the 49th parallel. British North America Boundary Commission, 1873.

DAWSON, G. M.—Report on climate, agricultural value, general geological features and minerals of economic importance of part of northern portion of British Columbia and Peace river country. Reprint from report of Canadian Pacific Railway, 1880. Published by Geological Survey.

DAWSON, G. M.—Preliminary note on the geology of the Bow and Belly rivers district, N.W.T., with special reference to the coal deposits. Report of Progress of Geol. Surv., 1880-81-82, Part B.

DAWSON, G. M.—Mineral wealth of British Columbia with annotated list of localities of minerals of economic value. Rep. Geol. Surv., 1887-88, Part R.

DAWSON, G. M.—Report on a geological examination of the northern part of Vancouver Island and adjacent coast. Report Geol. Surv., 1886, Part B.

DAWSON, G. M.—Note on coal-bearing rocks of Queen Charlotte Islands, B.C. Report of Progress, Geol. Surv., 1876-77.

DAWSON, G. M.—Preliminary report on physical and geological features of that portion of the Rocky mountains between latitudes 49° and 51° 30′. Report Geol. Surv., 1885, Part B.

DAWSON, G, M.—Note on coal measures of the Nanaimo coal-field. Report of Progress, Geol. Surv., 1876-77.

DAWSON, G. M.—Report on Peace river valley. Report of Progress, Geol. Surv., 1879-80.

DAWSON, G. M.—Geology of lignite formation at Quesnel. Report of Progress, Geol. Surv., 1875-76.

DAWSON, G. M.—Notes on coal rocks of Nicola valley. Report of Progress, Geol. Surv., 1876-77.

DAWSON, G. M.—Preliminary Report on geology and coal deposits of Bow and Belly rivers region. Report of Progress, Geol. Surv., 1880-82.

DAWSON, G. M.—General note on the mines and minerals of economic value of British Columbia. Report of Progress, Geol. Surv., 1876-77.

DAWSON, G. M.—Coal and lignite in Kamloops district. Report Geol. Survey, 1894, Vol. VII, Part B.

DOWLING, D. B.—Index to reports of Geol. Surv., 1883-84.

DOWLING, D. B.—Souris coal-field. Summary Report, Geoglogical Survey, 1902.

HARRINGTON, B. J—On the coals of the west coast. Report of Progress, Geol. Surv., 1872-73.

COAL. Bibliography.

LEACH, W. W.—Crows Nest Pass. Summary Report, Geol. Surv., 1901.

McCONNELL, R. G.—Report on the Cypress hills, Wood mountain. Report Geol. Surv., 1885, Part C.

McCONNELL, R. G.—Yukon district. Summary Report, Geol. Surv., 1899.

McCONNELL, R. G.—Yukon district, lignite areas. Summary Report, Geol. Surv., 1900.

McEVOY, JAMES.—Crows Nest pass. Summary Report, Geol. Surv., 1900.

McEVOY, JAMES.—Report on the geology and natural resources of the country traversed by the Yellowhead pass route from Edmonton to Tête Jaune Cache. Geol. Surv. Report, Vol. XI., Part D.

RICHARDSON, JAS.—Report on Nanaimo coal-fields, Vancouver island, B.C. Report of Progress, Geol. Surv., 1876-77.

RICHARDSON, JAS.—Report on part of Nanaimo coal-field. Report of Progress, Geol. Surv., 1871-72.

RICHARDSON, JAS.—Report on part of Comox coal-fields, Vancouver island. Report of Progress, Geol. Surv., 1871-72.

RICHARDSON, JAS.—Report on Cowitchen coal area, Vancouver Island, B.C. Report of Progress, Geol. Surv., 1876-77.

RICHARDSON, JAS.—Report on coal-fields of Skidegate, Queen Charlotte island, B.C. Report of Progress, Geol. Surv., 1872-73.

RICHARDSON, JAS.—Report on Comox coal-field, Vancouver island, B.C. Report of Progress, Geol. Surv., 1876-77.

ROBERTSON, W. F.—Annual Reports of the Minister of Mines for the Province of British Columbia. Victoria, B.C.

SELWYN, A. R. C.—Reports on borings north of Turtle mountain and on Souris river, Manitoba. Report of Progress, Geol. Surv., 1879-80.

TYRRELL, J. B.—Report on a part of Northern Alberta. Report of Geol. Surv., 1886, Part E.

MAPS OF THE GEOLOGICAL SURVEY COVERING COAL DISTRICTS.

Maps.

No. on List of Publications.

Nova Scotia and New Brunswick.

105. Cape Dauphin district.

106. Eastern part of Sydney coal field.

113. Western part of Sydney coal field.

184. Sheet 1 (Cape North Sheet), parts of Inverness and Victoria counties. Scale 1 mile to 1 inch.

185. Sheet 2 (Aspy Bay Sheet), part of Victoria County. Scale 1 mile to 1 inch.

186. Sheet 3 (Pleasant Bay Sheet), parts of Inverness and Victoria counties. Scale 1 mile to 1 inch.

COAL.

Maps.

187. Sheet 4 (Ingonish Sheet), part of Victoria County. Scale 1 mile to 1 inch.

188. Sheet 5 (Head-waters of Cheticamp River Sheet), parts of Inverness and Victoria Counties. Scale 1 mile to 1 inch.

189. Sheet 6 (North Cheticamp Sheet), part of Inverness County. Scale 1 mile to 1 inch.

190. Sheet 7 (North Shore Sheet), part of Victoria County. Scale 1 mile to 1 inch.

191. Sheet 8 (Head-waters Margaree River Sheet), parts of Inverness and Victoria Counties. Scale 1 mile to 1 inch.

192 Sheet 9 South Cheticamp Sheet), part of Inverness County. Scale 1 mile to 1 inch.

193. Sheet 10 (Englishtown Sheet), parts of Victoria and Inverness Counties. Scale 1 mile to 1 inch.

194. Sheet 11 (Margaree Sheet), parts of Inverness and Victoria Counties. Scale 1 mile to 1 inch.

195. Sheet 12 (Baddeck Sheet), part of Victoria County. Scale 1 mile to 1 inch.

196. Sheet 13 (Middle River Sheet), parts Inverness and Victoria Counties. Scale 1 mile to 1 inch.

197. Sheet 14 (Broad Cove Sheet), part of Inverness County. Scale 1 mile to 1 inch.

198. Sheet 15 (Whycocomagh Sheet), parts of Inverness and Victoria Counties. Scale 1 mile to 1 inch.

199. Sheet 16 (Port Hood Sheet), part of Inverness County. Scale 1 mile to 1 inch.

200. Sheet 17 (Loch Lomond Sheet), parts of Richmond and Cape Breton Counties. Scale 1 mile to 1 inch.

201. Sheet 18 (River Denys Sheet), parts of Richmond and Inverness Counties. Scale 1 mile to 1 inch.

202. Sheet 19 (Judique Sheet), part of Inverness County. Scale 1 mile to 1 inch.

203. Sheet 20 (L'Ardoise Sheet), part of Richmond County. Scale 1 mile to 1 inch.

204. Sheet 21 (Saint Peter Sheet), parts of Richmond and Inverness Counties. Scale 1 mile to 1 inch.

205. Sheet 22 (Strait of Canso Sheet), parts of Inverness, Richmond, Antigonish and Guysborough Counties. Scale 1 mile to 1 inch.

206. Sheet 23 (Arichat Sheet), part of Richmond County. Scale 1 mile to 1 inch.

652. Cape Dauphin Sheet, part of Cape Breton and Victoria counties.

653. Sydney Sheet, parts of Cape Breton and Victoria counties.

654. Little Glace Bay Sheet, part of Cape Breton county.

230. Cumberland coal fields Sheet.

82. Pictou coal field.

100. Index map of Springhill coal field.

145. Grand Lake Sheet, N.B.

162. Newcastle Sheet, N.B.

675. Map of principal mineral occurrences in New Brunswick.

812. Preliminary map of Springhill coal field.

British Columbia, Manitoba and North-West Territories. COAL. Maps.

225. Geological map of Cypress hills and Wood mountain districts.
158. Index map of coal and lignite outcrops in the Bow and Belly rivers districts.
171. Geological map of the Bow and Belly rivers districts.
249. Geological map of Northern Alberta.
224. Cascade coal basin.
223. Reconnaissance map of a portion of the Rocky mountains.
804. Orographic map of lower contour of Turtle mountain, Manitoba.
808. Geological sketch map of Blairmore, Frank coal fields, Alberta.
676. Yellowhead pass route, from Edmonton to Tete Jaune Cache.
87. Coal fields of Nanaimo and Comox.
121. Coal fields of Comox, Nanaimo and Cowitchin on Vancouver and adjacent islands.
139, 140, 141. Queen Charlotte islands.
767. Geological and topographical map of Crows Nest coal field, East Kootenay district, B.C.

COPPER.

COPPER.

Despite the falling off in the price of copper from an average of 16·117 cents per pound in 1901 to 11·626 cents per pound in 1902, the production of this metal in Canada in 1902 shows an increase of over 2·5 per cent as compared with the previous year. The total value of the output, however, is much less, a falling off of 26 per cent.

The total production in 1902 was 38,804,289 pounds, valued at $4,511,383, and made up by provinces as follows :—

	Lbs.
Quebec and New Brunswick	1,760,000
Ontario	7,408,202
British Columbia	29,636,057
Total	38,804,259

Copper.

Production.

TABLE 1.

COPPER.

ANNUAL PRODUCTION.*

Calendar Year.	Lbs.	Increase or Decrease.		Value.	Increase or Decrease.		Average Price per Pound.
		Lbs.	%		$	%	
				$			Cts
1886.......	3,505,000	... .	....	385,550	....	....	11·00
1887......	3,260,424	244,576	6·99	366,798	18,752	4·86	11·25
1888.......	5,562,864	2,302,440	70·60	927,107	560,309	152·70	16·66
1889......	6,809,752	1,246,888	22·40	936,341	9,234	0·99	13·75
1890.......	6,013,671	796,081	11·69	947,153	10,812	1·15	15·75
1891.......	8,928,921	2,915,250	48·40	1,149,598	202,445	21·37	12·87
1892......	7,087,275	1,841,646	20·62	818,580	331,018	28·79	11·55
1893......	8,109,856	1,022,381	14·40	871,809	53,229	6·50	10·75
1894.......	7,708,789	401,067	4·94	736,960	134,849	15·46	9·56
1895.......	7,771,639	62,850	·81	836,228	99,268	13·47	10·76
1896... ..	9,393,012	1,621,373	20·86	1,021,960	185,732	22·21	10·88
1897......	13,300,802	3,907,790	41·60	1,501,660	479,700	46·94	11·29
1898.......	17,747,136	4,446,334	33·43	2,134,980	633,320	42·17	12·03
1899.......	15,078,475	2,668,661	15·04	2,655,319	520,339	24·37	17·61
1900......	18,937,138	3,858,663	25·59	3,065,922	410,603	15·46	16·19
1901......	37,827,019	18,889,881	99·75	6,096,581	3,030,659	98·84	16·117
1902.......	38,804,259	977,240	2·58	4,511,383	1,585,198	26·00	11·626

* The production is altogether represented by the copper contained in ore, matte, &c., produced and shipped valued at the average market price for the year for fine copper in New York.

Note.—In the above table, increases are shown underlined, and decreases in the ordinary way.

COPPER.

Exports.

TABLE 2.

COPPER.

EXPORTS OF COPPER IN ORE, MATTE, ETC.

Calendar Year.	Pounds.	Value.
		$
1885	....	262,600
1886	....	249,259
1887	....	137,966
1888	....	257,260
1889	....	168,457
1890	....	398,497
1891	....	348,104
1892	....	277,632
1893	4,792,201	269,160
1894	1,625,389	91,917
1895	3,742,352	236,965
1896	5,462,052	281,070
1897	14,022,610	850,336
1898	11,572,381	840,243
1899	11,371,766	1,199,908
1900	23,631,523	1,741,885
1901	32,488,872	3,404,908
1902	26,094,498	2,476,516

Imports.

TABLE 3.

COPPER.

IMPORTS OF PIGS, OLD, SCRAP, ETC.

Fiscal Year.	Lbs.	Value.	Fiscal Year.	Lbs.	Value.
		$			$
1880	31,900	2,130	1891	107,800	10,452
1881	9,800	1,157	1892	343,600	14,894
1882	20,200	1,984	1893	168,300	16,331
1883	124,500	20,273	1894	101,200	7,397
1884	40,200	3,180	1895	72,062	6,770
1885	28,600	2,016	1896	86,905	9,226
1886	82,000	6,969	1897	49,000	5,449
1887	40,100	2,507	1898	1,050,000	80,000
1888	32,300	2,322	1899	1,655,000	246,740
1889	32,300	3,288	1900	1,144,000	180,990
1890	112,200	11,521	1901	951,500	152,274
1902 { Copper, old and scrap or in blocks .....Duty free				109,600	11,878
1902 { Copper in pigs or ingots .... "				1,657,600	213,954
Total, 1902				1,767,200	225,832

COPPER.

Imports.

TABLE 4.

COPPER.

IMPORTS OF MANUFACTURES.

Fiscal Year.	Value.
	$
1880	123,061
1881	159,163
1882	220,235
1883	247,141
1884	134,534
1885	181,469
1886	219,420
1887	325,365
1888	303,459
1889	402,216
1890	472,668
1891	563,522
1892	422,870
1893	458,715
1894	175,404
1895	251,615
1896	285,220
1897	264,587
1898	786,529
1899	551,586
1900	1,090,280
1901	951,045

Year	Article	Duty.	Pounds.	$
1902.	Copper in bolts, bars and rods, in coils, or otherwise in lengths not less than 6 feet, unmanufactured	Free.	5,509,500	767,315
	Copper, in strips, sheets or plates, not planished or coated, &c	"	2,252,500	307,429
	Copper tubing in lengths not less than 6 feet, and not polished, bent or otherwise manufactured	"	198,212	43,359
	Copper rollers, for use in calico printing, imported by calico printers for use in their own factories	"	....	13,133
	Copper and manufactures of:—			
	Nails, tacks, rivets and burrs or washers	30 p. c.	....	7,454
	Wire, plain, tinned or plated	15 "	603,268	93,891
	Wire cloth, &c	25 "	....	1,932
	All other manufactures of, N.O.P.	30 "	....	47,009
	Total	....	....	1,281,522

New Brunswick.

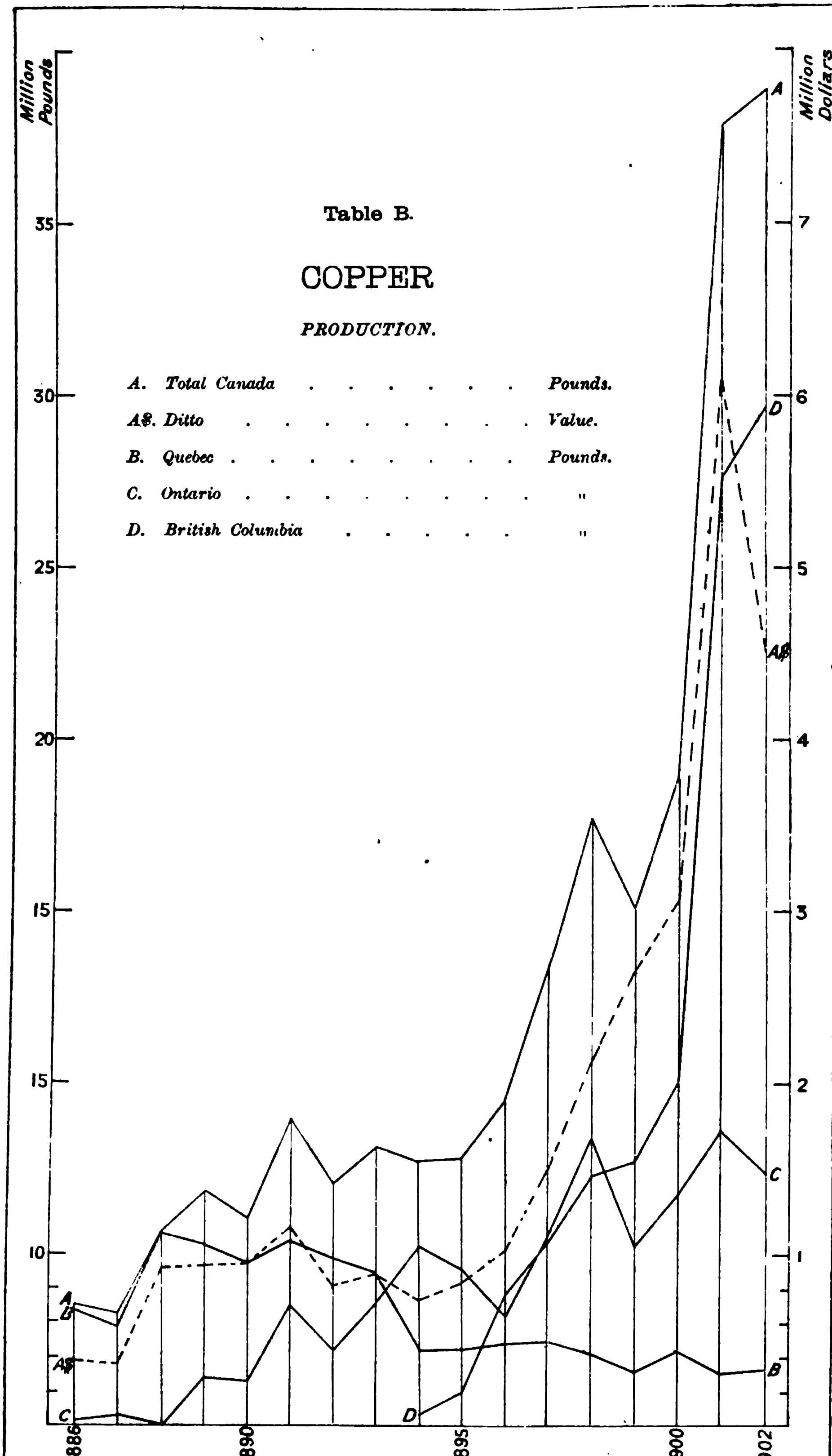
NEW BRUNSWICK:

There was a small production of copper in this province by the Intercolonial Copper Company at Dorchester.

Quebec.

QUEBEC:

As usual the copper production in Quebec was derived from the pyrites ores of the Eastern Townships. Statistics of production since 1886 are given below.



Million Pounds
Million Dollars
Table B.
COPPER
PRODUCTION.
A. Total Canada . . . . Pounds.
A$. Ditto . . . . Value.
B. Quebec . . . . Pounds.
C. Ontario . . . . "
D. British Columbia . . . . . . "
35
30
25
20
15
15
10
7
6
5
4
3
2
1
A
B
A$
C
D
1886
1890
1895
1900
1902

COPPER.

Quebec.

TABLE 5,

COPPER.

QUEBEC :—PRODUCTION.

Calendar Year.	Pounds.	Value.
		$
1886	3,340,000	367,400
1887	2.937,900	330,514
1888	5,562,864	927,107
1889	5,315,000	730,813
1890	4,710,606	741,920
1891	5,401,704	695,469
1892	4,883,480	564,042
1893	4,468,352	480,348
1894	2,176,430	208,067
1895	2,242,462	241,288
1896	2,407,200	261,903
1897	2,474,970	279,424
1898	2,100,235	252,658
1899	1,632,560	287,494
1900	2,220,000	359,418
1901	1,527,442	246,178
1902	1,640,000	190,666

Ontario.

ONTARIO :

The nickel copper ores of the Sudbury district are responsible for the major portion of the copper production in Ontario in recent years. The Canadian Copper Company and Mond Nickel Company continued to operate their several properties, while the Lake Superior Power Company carried on extensive development work at the Gertrude and Elsie mines. The total quantity of nickel copper ore mined in 1902 was 269,538 tons, while the quantity treated at the smelters was 211,847 tons. Matte produced at Mining Company's smelters was 23,211 tons of ordinary matte and 2,100 tons of Bessemer matte. Some of the ordinary matte was further treated and Bessemerized at

the Ontario Smelting Company's works at Copper Cliff. A small output of copper was also obtained from the Bruce mines. COPPER. Ontario.

The total contents of copper in the ore, matte, etc., shipped, was 7,408,202 pounds, valued at $861,278, being slightly less than the output of the previous year.

Statistics of production since 1886, are given in Table 6 following :

TABLE 6.

COPPER.

ONTARIO :—PRODUCTION.

Calendar Year.	Pounds.	Value.
		$
1886	165,000	18,150
1887	322,524	36,284
1888	....	....
1889	1,466,752	201,678
1890	1,303,065	205,233
1891	3,527,217	454,129
1892	2,203,795	254,538
1893	3,641,504	391,461
1894	5,207,679	497,854
1895	4,576,337	492,414
1896	3,167,256	344,598
1897	5,500,652	621,023
1898	8,375,223	1,007,539
1899	5,723,324	1,007,877
1900	6,740,058	1,091,215
1901	8,695,831	1,401,507
1902	7,408,202	861,278

BRITISH COLUMBIA. British Columbia.

The production of copper in British Columbia in 1902 was 29,636,057 lbs. or 14,818 tons, an increase of 7 per cent over that of the previous year, and nearly three times the output of 1900. Owing to the lower

COPPER.

British Columbia.

price of copper in 1902, however the total value of the output for the year was less by over one million dollars than that of 1901.

Copper mining in British Columbia practically dates from 1894, and statistics of production since that year are shown in table 7.

TABLE 7.

COPPER.

BRITISH COLUMBIA—PRODUCTION.

Calendar Year.	Copper contained in ores, matte, &c.	Increase.		Value.
	Lbs.	Lbs.	%	
1894	324,680	....	...	$ 31,039
1895	952,840	628,160	193	102,526
1896	3,818,556	2,865,716	301	415,459
1897	5,325,180	1,506,624	39	601,213
1898	7,271,678	1,946,498	36	874,783
1899	7,722,591	450,913	6	1,359,948
1900	9,977,080	2,254,489	29	1,615,289
1901	27,603,746	17,626,666	177	4,448,896
1902	29,636,057	2,032,311	7	3,445,488

The production by districts for the last three years was as follows:

	1900.	1901.	1902.
Cassiar	....	....	6,258
East Kootenay	2,147	3,272	8,048
West Kootenay—			
Ainsworth	....	....	9,537
Nelson	36,929	1,599,449	491,144
Trail Creek	2,071,865	8,333,446	11,667,807
All other	....	....	1,000
Yale—			
Boundary	5,672,177	14,511,787	14,955,582
Ashcroft, Kamloops	....	39,920	....
Coast districts	2,193,962	3,115,872	2,496,681
	9,977,080	27,603,746	29,636,057

The following short report giving the result of an investigation of one of Canada's best known copper districts is reproduced from the Summary Report of the Geological Survey Department for 1902.

COPPER.
Bruce mines district.

GEOLOGY OF THE BRUCE MINES DISTRICT.

At the beginning of June 1902 field work was begun in the Bruce Mines District, Algoma, Ontario. Mr. Theo. Denis accompanied Mr. E. D. Ingall, who had charge of making a study and a detailed map of an area some twenty miles square, embracing a district which is important from an economic standpoint, on account of the attention now being given to its copper deposits, and also from the presence of iron ore. The area comprises the townships of Plummer, Johnson, Tarbutt, Laird, McDonald, Meredith, Aberdeen, Kehoe, McMahon, Chesley additional and a portion of the Garden river Indian reserve. The object was to study, as far as conditions allowed, the relation of the mineral deposits to the inclosing rocks and their modes of occurrence; also to verify and correct the geological mapping as given in the atlas accompanying the Geology of Canada of 1863. Mr. E. D. Ingall undertook the careful study of limited mineralized areas, investigating their lithology, the manner of deposition and the exploitation of their mineral deposits in detail, and to Mr. Denis was assigned the work of the mapping of the general distribution of the rocks of the district and the topography required for the construction of a map. As there were no maps of the district available, on a convenient scale, the greater part of the season was devoted to topographical work. All the roads were surveyed with micrometer and railroad compass, some 250 miles being covered. The rock-exposures along these roads were also located, thus affording a good skeleton of the geology, which however, requires additional work to fill in the gaps before completing the map. Towards the end of the season, Mr. Denis joined Mr. Ingall and assisted in carrying out the investigations at the several points which had been chosen for detailed geological work.

The district under consideration, forms part of the typical Huronian area, studied and mapped out by Alex. Murray in the early days of the Geological Survey of Canada. The map, on a scale of eight miles to the inch, in the atlas which accompanies the Geology of Canada, 1863, gives a good idea of the general distribution of the rocks; but as the material for the construction of the map was gathered at a time when the country was bush-covered and travelling through it difficult, it can be easily understood that the geological lines require correction in places, in the light of later observations carried out under more favourable conditions.

COPPER.

Bruce mines district.

The sequence of the rocks of the Huronian series, as observed by Murray, together with his descriptions, will be found in the Geology of Canada, 1863, but since then, some of the members of the series have been the object of more thorough investigation. One of the prominent features of the formation is the ' slate conglomerate," which has been divided in the Geology of Canada into two members, the lower and the upper. The aggregate thickness of this rock has been estimated by Murray to be over 4,000 feet. It is similar to the 'breccia conglomerate' of the Temiskaming region, which has been the subject of thorough investigation by Dr. Barlow of this department. This is well described in his report on the Temiskaming region. (Ann. Rep. of the Geol. Surv. vol. X. pt. I.) Dr. Barlow believes it to have had a pyroclastic origin. The following is an abstract of his description. 'The rock is composed of a groundmass or matrix in which are embedded pebbles and fragments of biotite granite or granitite, hornblende granite, diabase diorite, &c. These vary greatly in size from small grains to boulders of fifteen inches in diameter and even larger. They are very unevenly distrbuted throughout the groundmass, sometimes in aggregates, the individuals being very close together, whereas in other places they are very sparsely disseminated, leaving between them wide interspaces of the groundmass. The granitite fragments are by far the most abundant. This material is usually of a pink colour and coarse in texture. A thin section prepared from one of the pebbles shows the rock to be greatly decomposed and to consist of orthoclase, which predominates, with plagioclase and microcline. The feldspar is much decomposed, consequently turbid and filled with sericite, epidote and calcite; the bi-silicates are almost entirely altered to chlorite. The quartz is of the ordinary granitic variety; it has a somewhat wavy extinction, but does not show other proofs of having undergone great strain. Hornblende and biotite were probably originally present but have been totally altered to chlorite.'

The other rocks represented by pebbles in the groundmass have also been studied; the diabase fragments are fine-grained and show much decomposition. There are also present fragments of greatly crushed and stretched felspathic quartzite.

The matrix or groundmass in which these pebbles and fragments are embedded was found by Dr. Barlow to consist mainly of granitic debris, the fragments as a rule being simple minerals with angular or irregular outlines, indicating that they were not subjected to the trituration usually shown by constituents of ordinary clastic rocks. The minerals represented, as a rule, are orthoclase, plagioclase, microcline,

with chlorite, sericite, epidote and zoisite, as well as magnetite, ilmenite and pyrite; quartz is also present, frequently showing pronounced uneven extinction. COPPER. Bruce mines district.

This breccia conglomerate is underlain by a series of quartzites, felspathic in character, the textures of which vary considerably from very fine grained, in places vitreous quartzites, to coarse grained, almost conglomeratic in appearance. Overlying the breccia conglomerate is another group of quartzites, the lower members of which are also felspathic. This arkose character gradually disappears and the upper members are vitreous non-felspathic quartzites ranging in colour from dark purple to perfectly white, containing in one case the red jasper pebbles which give rise to the red jasper conglomerate.

This series of quartzites overlying the breccia conglomerate has been divided into several individual members by Murray, who has mapped out their distribution with sharp boundaries. These contacts in the field, wherever observed last summer, were however not found to be very well defined, but seen to be more of the nature of a merging of the rocks into one another, the character of the strata changing gradually.

The district is traversed by belts of igneous rocks which differ greatly in importance, varying from quite small areas to others many square miles in extent. The different areas vary considerably also both in mineral constitution and texture. They are mentioned in the 'Geology of Canada,' but are not defined on the map of the Huronian region which accompanies it. As the mineral deposits of the district seem to be largely connected with these rocks, it would be important to delimit them and study them more closely than could be done in the general examination made of the district. As a beginning towards this, some forty thin sections of specimens collected last summer are being made and will be examined as soon as they arrive.

These igneous rocks are referred to in the Geology of Canada as overflows. Although the definite conclusion as to their being so or not cannot be arrived at without more field investigation, yet the evidence gathered so far would certainly in most cases assign to them an intrusive rather than an overflow character.

The region has received attention chiefly on account of occurrences of copper ores, although some properties have been prospected for iron ores. The copper occurs in the form of sulphides, the common ore being chalcopyrite. Bornite occurs intermixed with the chalcopyrite in the ore, especially in the surface zone.

COPPER.

Bruce mines district.

Within the area examined, the points at which most work hrs been done and which were therefore selected for especial studies of the mode of occurrence of the copper ores were The Bruce, Wellington and Huron Copper Bay, the Rock Lake, the Cameron and the Richardson mines. Besides these, a number of other properties were examined where only surface prospecting had been done.

By far the most extensive developments made are those of the mines in the vicinity of Bruce Mines on the shore of Lake Huron, about thirty five miles east of Sault Ste. Marie, Ontario.

Although these mines were recently reopened, their history dates back over half a century, work having been commenced in 1846. The mines are situated on a group of veins whose outcroppings showing first on the shore at a point about a mile east of the dock at Bruce Mines, have been traced for over a mile and a half in a general north-westerly direction to the limit of the workings of the Huron Copper Bay mine.

The veins are unquestionably fissures in an extensive area of, 'greenstone.' The final decision as to the exact nature of this igneous mass and its relationship to the surrounding sedimentaries is a matter requiring further work in the field and microscopic examinations of the rock specimens brought in. However as the result of a preliminary examination of a couple of thin sections by Dr. A. E. Barlow, petrographer to the department, the rock would appear to be uralite diabase. A number of dykes of a more compact diabase cut both the general mass of the older rock and the series of veins.

The area of diabase above mentioned shows a width in a northerly and southerly line of about a mile from the shore line to where the sedimentary rocks of the series first appear. No boundaries were located to its extension east and west, as it passed outside of the area under study. The large islands closing in the mouth of Bruce Mines bay are also 'greenstone,' but the shores of the western end of the bay being drift covered it could not be determined whether or not they connect with the main area of the mainland to the north. There seems to be a possibility that a belt of quartzite may intervene which has determined the erosion of the hollow now forming the bay.

On the northern side this greenstone is followed by quartzite with which is associated a thin bed of impure limestone. Near the westerly working of the Huron Copper Bay mine this limestone bed seems to be cut off abruptly by the greenstone, although the actual contact must be in the low ground intervening between the exposed

surfaces of the two rocks. The limestone can be traced pretty continuously in a easterly direction to the edge of the area examined. Only at one place however is the actual contact exposed, a wide stretch of drift intervening as a rule. At the point above mentioned the contact seems to be distinctly an intrusive one, tongues of the greenstone cutting the limestone. Much more precise exploration would be required however to decide whether these represented tongues of a dyke cutting both rocks, and younger than both or whether thereby the intrusive nature of the whole mass is to be considered proved. Passing easterly from this point, which is near the road between the village and the Canadian Pacific Railway station, it is found that a comparatively thin bed of red and dark brown quartzites intervenes between the greenstone, and the limestone, the latter showing as a little ridge. Between this ridge and the rock exposures of slate conglomerate along the railroad, about half a mile to the north, the section is practically all drift-covered in the vicinity of the road. Search would have to be made therefore in the bush-covered land east and west of this point for more continous exposures in order to work out the actual succession of the sedimentaries lying to the north of the igneous area in which the mines lie.

COPPER

Bruce mines district.

Without attempting to settle these yet outstanding questions the main features of the economic deposits at this point may be summed up as presenting a series of large fissure veins cutting an extensive mass of 'greenstone,' the latter being bounded on the south by the waters of Lake Huron and on the north by the quartzites, limestone and slate conglomerates of the Huronian series.

In an easterly direction the southern limit of the greenstone is shown toward the bottom of the eastern lobe of Bruce Mines bay, where the white quartzite of Murray's map comes in. The quartzite is continuous along the eastern shore of the bay, where, however, it is seen to be cut by numerous basic dykes.

The sedimentaries of the series are seen everywhere in the vicinity of this group of mines to dip at low angles toward the north. Along the shore of Lake Huron, however, westerly from Bruce Mines bay, the dip is southerly, exhibiting thus the order side of the anticlinal fold described and mapped by Murray.

The veins worked in this group of mines consist, as previously stated, of fissures. They carry the copper in the form of different sulphides, chiefly chalcopyrite, in a gangue of quartz. At places the gangue is partly dolomitic, but the former mineral is very largely predominant as

COPPER.

Bruce mines district.

evidenced by the material of the waste piles around the workings. Near their outcrops, the veins are said to have carried a higher percentage of copper than below, owing to the presence of bornite and other rich sulphides of the metal. The presence of these minerals is probably due, as would elsewhere appear, to secondary enrichment.

A preliminary examination of the lower levels of the Wellington and Huron Copper Bay workings showed chalcopyrite with some pyrite disseminated through a gangue of white quartz. In the Wellington and Huron Copper Bay mines, the veins have been worked out to great widths, excavations often reaching widths of 25 to 30 feet. Of course there are many places where the veins narrowed down to not more than four feet in thickness, but ten feet might perhaps be accepted as an average of the thickness all the way through. At the o'd Bruce mine the veins are seen to be narrower and in the main workings would not average possibly more than five feet.

The totel length attained in the Bruce workings would measure about 2,000 feet, whilst the combined length of the Wellington and Huron Copper Bay mines would measure nearly 2,500 feet. The workings at the Bruce attained depths of 250 to over 300 feet and at the Wellington the average of the depth attained in the workings would be about the same although Bray's shaft was put down to about 1,060 feet. The area of the veins stoped ont, as shown on the old plans, would measure approximately as follows, viz:—At the Bruce Mine about 225,000 square feet which, assuming a depth of 300 feet for the mine, would represent a length of say 750 feet of vein excavated. At the Wellington, etc., a total measurement is shown of about 600,000 square feet, which would represent for a depth of say 300 feet, an equivalent in length of 2,000 feet. In both cases, it must be born in mind that these represent workings on two main veins close together and parallel to each other as worked in these two mines. In the Wellington &c., mines, these were known as the New Lode and Fire Lode. They paralleled each other for about 1,300 feet, but joined together to form a single vein at the east and western ends on the workings.

The westerly part of the Bruce workings are situated on the main lode and its branches for about 1,300 feet, whilst east of this, for about 600 feet, the chief excavations are on two veins, known as the Trial and Dodge veins. A good deal of prospecting work was done on minor veins and branches in the vicinity of these two chief mines, and also in veins which outcrop in the 4,000 feet of distance intervening between the Bruce and Wellington workings, but much more develop-

ment will need to be done before the question as to the practical continuity of the series of fissures and their profitable nature can be settled. An excavation called Taylor's shaft, from which it was said some test drifts were run, was sunk about midway of the distance between the two mines, but no details are available as to the results attained. The particulars given above refer to the work done during the first period of the history of these mines by the West Canada Copper Company and its predecessors. The period ended with the final cessation of work in 1876. When this company was working at its strongest it employed as many as 380 men, and for the period of years from 1858 to 1875 produced about 37,378 long tons of concentrates having a total content of nearly 7,500 long tons of copper, valued at over $2,900,000, The average price received for the copper during this whole period of eighteen years would thus be somewhat over 17 cents per pound. Since 1858, however, the price of this metal has fallen off considerably. In that year the company obtained an average of 21 cents per pound for its copper, whereas the figures for 1875 show an average value for their product of less than 16 cents per pound. When the present company bought the mines a few years ago it reopened them and some further work was done, of which, however, we have as yet no complete data. At present nothing is being done other than to keep the plant and mines in order. In connection with the operations of the present company, the mines have been fully re-equipped with modern machinery for mining and ore-dressing, the mill having a capacity of 400 tons per day. As it is intended to give full particulars of this important group of mines in the complete report to follow later, nothing further need be stated here.

COPPER.

Bruce mines district.

The final failure of the first attempt to work these mines seems to have been due to a variety of causes, many of which have ceased to be operative with the progress of opening up of the district, and it becomes a question as to whether successful work could not again be carried on with careful management and the improved plant and methods available.

The Rock Lake mine is situated some fourteen miles north of Bruce Mines village. It is equipped with a complete mining plant, including hoists, air compressor, drills, etc., and with a mill with a capacity of 100 to 125 tons per 24 hours. The latter is situated on the shore of Rock lake, nearly two miles west from the main shaft with which it is connected by a tramway. Transportation is afforded from the mill by the Bruce Mines and Algoma Railroad, which connects with the Canadian Pacific Railway at Bruce Mines station, with an extension to the lake shore at Bruce Mines village.

COPPER.

Bruce mines district.

The ore consists of chalcopyrite with some bornite, &c., in a gangue consisting mostly of white quartz with which is intermixed at places a good deal of ankerite, the ochreous decomposition product of the latter constituting a marked feature of the outcroppings at places. The developments made are situated along what appears to be a shattered zone at the contact of the red quartzite and the 'upper slate conglomerate' of Murray. The quartzite proper extends for a width across the strike of about a mile southerly, and the 'slate conglomerate,' etc., about an equal distance northerly. The workings are situated along a narrow subsidiary valley about half way up and running lengthwise of the hills of slate conglomerate flanked with quartzite which rise to a height of some 400 or 500 feet above the level of Rock lake. In the vicinity of the mine buildings and main workings the width of the zone of shattered quartzite exposed is from 500 to 700 feet. Passing northward, this is followed by a belt of green schistose rock, showing a width of outcrop of about 400 feet. For about 400 feet further there are no rock exposures until the foot of the northern ridge is reached, where the typical 'slate conglomerate' emerges abruptly from beneath the cover. This belt exhibits the characteristic features elsewhere found of well rounded pink boulders and pebbles of granitic rock, &c., scattered throughout a dark greenish-grey matrix of slaty appearance.

The veins worked in the main shaft and connected workings are in the schistose belt. Other less extensive workings to the south of these are in veins in the shattered quartzite zone. It seems probable that the schistose belt above mentioned represents merely a portion of the 'slate conglomerate' in which schistosity has been developed by the disturbing force that at the same time produced the series ef veins and shattered the adjacent quartzite.

The general dip of the formation is southerly about 25° although near the mill there is evidence of a somewhat steeper dip in the flanking quartzite, followed in ascending the hill northward by a flat anticlinal and synclinal fold before reaching the main ridge of slate conglomerate.

A comparatively small dyke of greenstone, measuring from 100 to 150 feet in width runs with a general north-westerly strike roughly parallel with the general trend of the veins. It lies about 100 feet to the south of the main shaft, and at the west end passes close to the north side of the mile. The developments made up to October, 1902, consisted of the main shaft and workings together with a considerable amount of surface development for a distance of some 1,500 feet east and

a number of test pits, &c., along the same general direction westerly for about a mile and a half. At the most of these points ore has been exposed showing chalcopyrite desseminated through a quartz or quartz and ankerite gangue. Of the relationships of the veins to those worked in the main shaft, nothing could be definitely stated without still further detailed mapping and study, owing to the disturbed condition of the formation previously alluded to.

COPPER
Bruce mines district.

The main shaft, which is practically vertical, at the date of the last visit made had attained a depth of 400 feet. From it, levels had been driven east and west at depths of 100 feet and 200 feet, testing the vein for a length of nearly 600 feet. At the bottom of the shaft a small crosscut to the south reached the main vein at about 35 feet, which had been followed west in a drift for about 30 feet. The ore mined was being taken from above the second level, the stopes exhibiting a width of about 20 feet.

Apart from the small dyke already mentioned, the only intrusive rocks anywhere in the vicinity are represented by two considerable ranges of greenstone traversing the sedimentaries at distances of half a mile north and south of the mine respectively and with a general trend parallel to that of the formation.

About two and a half miles north-east from Desbarats station on the Canadian Pacific Railway (Algoma branch) is the mine known as the Cameron or Stobie. At this place a fissure vein is seen cutting a ridge of red quartzite. On this vein a shaft has been sunk some 150 feet in depth from which, at 100 feet down, have been run drifts east and west totalling in length about 150 feet. The outcropping of the vein to the east of the shaft is not visible, being covered, but it has been stripped west of the shaft for a distance of 150 feet, where it runs under the deep soil of the adjacent farming land of the valley. Seventeen hundred feet further west on the rocky ridges opposite the mine, small surface working have also shown the existence of ore. These are roughly on the strike of the Cameron mine vein, but whether they are to be taken as representing its actual extension or not is doubtful. The outcroppings near the shaft show a composite vein of about four feet in width, the ore being chalcopyrite in a gangue of white quartz. Some specimens show plainly surface change of the chalcopyrite to bornite. The vein in the workings shows a dip of 75° to the south and a width at places of about 12 feet made up of subordinate branches with 'horses' of quartzite.

Following the quartzite ridge southerly for about 700 feet, several small greenstone dykes cut across the quartzite in a direction roughly

COPPER.

Bruce mines district.

parallel to that of the vein. About 600 feet north-easterly from the shaft a coarser greenstone outcrops in one or two places, about on the run of a belt of the same rock visible in the ridges on the other side of the valley, where it shows a width of at least 125 feet. If this belt is actually continuous underneath the soil of the valley, it would thus pass about 400 feet north of the vein and with a course generally parrallel to it, whilst the smaller dykes before mentioned would probably represent tongues connected witn it. The mine is equipped with power drills, hoist and pumps suitable for carrying on development work.

The workings known as the Richardson mine are situated about two miles and half north of Desbarats village near the south-east end of Desbarats lake. These consist of a small prospecting shaft and a number of shallow pits and trenches extending over a distance of about three-quarters of a mile along the strike of a series of greenstone dykes which cut the jasper conglomerate of the sedimentary series. The evidences of the intrusive nature of the greenstone are here very marked, long narrow strips and lenses of the jasper conglomerate being included in the igneous mass. Some of the mining work done here is altogether in the greenstone, as in the case of the before mentioned shaft. Here, as so frequently observable elsewhere in the district, the rock is much decomposed and the resulting ochreous material has stained it, giving a very tempting ferruginous appearance, whilst in the jointing, etc., it has at times consolidated to form fairly good hematite ore. Most of the trenching and test pitting east of this shaft has evidently been done with a view to the examination of the contacts along these inclusions of jasper conglomerate. At all the points uncovered, the ochreous material and stain were much in evidence and at some points a little chalcopyrite with malachite stain show the presence of copper in small quantity.

The Stobie iron mine is amongst the older discoveries of the district. It is situated near the western end of Gordon lake. The openings made consist of a rock-cut in a ridge of white quartzite, run in to catch a small vein of hematite averaging about five feet in width at the outcrop. In the face of the bluff the vein in going upward splits into two branches, each about three feet thick. On the bare rock surface of the top of the ridge it seems to be represented only by a number of small stringers of ore. From the end of the open cut, a tunnel has been run in, but this is now closed by a cave-in at a distance of about 30 feet from the mouth.

It is said that several thousand tons of good ore were shipped from this opening many years ago, a statement which is borne out by the

existence of a stope above the tunnel, measuring about 80 feet in length by 50 feet in height, and having a width varying from 3 to 8 feet. COPPER. Bruce mines district.

The quartzite has a strike at this point of N. 55° W., and dips about 45° to the south at the bottom of the ridge, curving over, however, till the dip flattens out to about 20° on top. About a quarter of a mile to the north, an east and west ridge of greenstone rises up, representing evidently an intrusion through the quartzites.

At a number of other points in the district exploratory work has been done on ferruginous outcroppings of a somewhat similar nature, either in the greenstone or in the inclosing rocks near the contact. These places show all grades of material from ochreous stained rock to the consolidated ochreous product constituting specimens of good hematite. At none of the points visited, however, had any large bodies of iron ore been proved to exist.

GRAPHITE.

GRAPHITE.

The production of graphite in 1902, including crude and manufactured products, was according to returns received 1,095 tons valued at $28,300. This output was derived from the operation of the Canada Paint Co. at their mine near Fairville station, New Brunswick, the North American Graphite Company at Buckingham, Que., and the Ontario Graphite Co. at the Black Donald mine, Brougham township, Renfrew county, Ontario.

Statistics of production, exports and imports are given in the following tables :—

GRAPHITE.

Production.
Exports.

TABLE 1.

GRAPHITE.

ANNUAL PRODUCTION.

Calendar Year.	Tons.	Value.
1886	500	$4,000
1887	300	2,400
1888	150	1,200
1889	242	3,160
1890	175	5,200
1891	260	1,560
1892	167	3,763
1893	nil.	nil.
1894*	3	223
1895	220	6,150
1896	139	9,455
1897	436	16,240
1898	......	13,698
1899	1,130	24,179
1900	1,922	31,040
1901	2,210	38,780
1902	1,095	28,300

* Exports.

TABLE 2.

GRAPHITE.

EXPORTS.

Calendar Year.	Value.	Calendar Year.	Value.
1886	$ 3,586	1895	$ 4,833
1887	3,017	1896	9,480
1888	1,080	1897	4,325
1889	538	1898	13,098
1890	1,529	1899	22,490
1891	72	1900	46,197
1892	3,952	1901	35,102
1893	38	1902	24,839
1894	223		

		Cwt.	
1902	Crude	17,722	$23,097
	Manufacturers of		1,742
			$24,839

TABLE 3.

GRAPHITE.

IMPORTS OF RAW AND MANUFACTURED GRAPHITE.

GRAPHITE.

Imports.

Fiscal Year.		Plumbago.	Manufactures of plumbago.	
			Black-lead.	Other Manufactures.
1880		$1,677	$18,055	$2,738
1881		2,479	26,544	1,202
1882		1,028	25,132	2,181
1883		3,147	21,151	2,141
1884		2,891	24,002	2,152
1885		3,729	24,487	2,805
1886		5,522	23,211	1,408
1887		4,020	25,766	2,830
1888		3,802	7,824	22,604
1889		3,546	11,852	21,789
1890		3,441	10,276	26,605
1891		7,217	8,292	26,201
1892		2,988	13,560	23,085
1893		3,293	16,595	23,051
1894		2,177	17,614	16,686
1895		2,586	13,922	21,988
1896		2,865	18,434	19,497
1897		1,406	17,863	20,674
1898		1,862	19,638	32,653
1899		4,979	21,334	36,490
1900		4,437	22,078	38,440
1901		2,357	25,646	49,890
	Duty.			
1902 Plumbago, not ground, &c.	10 p.c.	$3,649		
1902 Black-lead	25 "	....	$20,467	
1902 Plumbago, ground and manufactures of N.E.S.	25 "	....	....	$15,021
1902 Crucibles, clay or plumbago	....	....	....	28,635
Total, 1902	....	$3,649	$20,467	$43,656

GYPSUM.

GYPSUM.

The production of gypsum, plaster of Paris, etc., in Canada in 1902, reached a total of 333,599 tons valued at $379,479, or an average of $1.14 per ton. Compared with the previous year the output shows an increase of 38,246 tons or 13 per cent in quantity and $19,129 or over 5 per cent in value.

GYPSUM.

Production.

The production was made up as follows:—

—	Tons.	Value.	Value per Ton.
Crude gypsum	316,225	$280,662	$ 0 89
Calcined and land plaster	4,841	28,379	5 86
Plaster of Paris and terra alba	12,533	70,438	5 62
	333,599	$379,479	$ 1 14

The province of Nova Scotia is the most important producer, with an output of 206,087 tons which is practically all crude gypsum. New Brunswick ranks next in importance, with an output of 124,041 tons, a large part of which is plaster of Paris. In Ontario and Manitoba the production was 1,917 tons and 1,554 tons respectively, gypsum having been mined in the latter province during the past two years only.

Statistics of production, exports and imports, are given in the following tables:—

TABLE 1.

GYPSUM.

ANNUAL PRODUCTION.

Calendar Year.	Tons.	Value.	Average price per ton.
1886	162,000	$178,742	$ 1 10
1887	154,008	157,277	1 02
1888	175,887	179,393	1 01
1889	213,273	205,108	0 96
1890	226,509	194,033	0 86
1891	203,605	206,251	1 01
1892	241,048	241,127	1 00
1893	192,568	196,150	1 02
1894	223,631	202,031	0 90
1895	226,178	202,608	0 89
1896	207,032	178,061	0 86
1897	239,691	244,531	1 02
1898	219,256	232,515	1 06
1899	244,566	257,329	1 05
1900	252,101	259,009	1 02
1901	293,799	340,148	1 16
1902 Nova Scotia	206,087	181,425	0 88
1902 New Brunswick	124,041	170,153	1 37
1902 Ontario	1,917	7,699	4 02
1902 Manitoba	1,554	20,202	13 00
Total, 1902	333,599	379,479	1 14

GYPSUM.

Production.

TABLE 2.

GYPSUM.

PRODUCTION ACCORDING TO GRADE OF PRODUCT.

Calendar Year.	Crude Gypsum.			Calcined and Land Plaster.			Plaster of Paris and Terra Alba.		
	Tons.	Value.	Value per Ton.	Tons.	Value.	Value per Ton.	Tons.	Value.	Value per Ton.
		$	$ c.		$	$ c.		$	$ c.
1897......	228,416	187,918	0 82	1,956	4,753	2 43	9,319	51,860	5 62
1898......	208,061	174,445	0 84	1,583	4,574	2 89	9,612	53,496	5 57
1899......	233,819	198,831	0 85	717	2,246	3 13	10,030	56,252	5 61
1900......	240,970	200,323	0 83	1,523	4,806	3 15	9,608	53,880	5 60
1901......	280,286	236,877	0 84	3,139	14,574	4 64	10,374	88,697	8 55
1902......	316,225	280,662	0 89	4,841	28,379	5 86	12,533	70,438	5 62

TABLE 3.

GYPSUM.

ANNUAL PRODUCTION BY PROVINCES.

Calendar Year.	Nova Scotia.		New Brunswick.		Ontario.		Manitoba.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
		$		$		$		$
1887.. ...	116,346	116,346	29,102	29,216	8,560	11,715		
1888	124,818	120,429	44,369	48,764	6,700	10,200		
1889......	165,025	142,850	40,866	49,130	7,382	13,128		
1890......	181,285	154,972	39,024	30,986	6,200	8,075		
1891......	161,934	153,955	36,011	33,996	5,660	18,300		
1892......	197,019	170,021	39,709	65,707	4,320	5,399		
1893......	152,754	144,111	36,916	41,846	2,898	10,193		
1894......	168,300	147,644	52,962	48,200	2,369	6,187		
1895 ..	156,809	133,929	66,949	63,839	2,420	4,840		
1896	136,590	111,251	67,137	59,024	3,305	7,786		
1897......	155,572	121,754	82,658	118,116	1,461	4,661		
1898......	132,086	106,610	86,083	121,704	1,087	4,201		
1899......	126,754	102,055	116,792	151,296	1,020	3,978		
1900......	138,712	108,828	112,294	145,850	1,095	4,331		
1901......	170,100	136,947	121,595	189,709	1,504	5,692	600	7,800
1902	206,087	181,425	124,041	170,153	1,917	7,699	1,554	20,202

GYPSUM.

Exports.

TABLE 4.

GYPSUM.

EXPORTS OF CRUDE GYPSUM.

Calendar Year.	Nova Scotia.		New Brunswick.		Ontario.		Total.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
1874	67,830	$ 68,164	......	......	......	......	67,830	$ 68,164
1875	86,065	86,193	5,420	$ 5,420	......	......	91,485	91,613
1876	87,720	87,590	4,925	6,616	120	$ 180	92,765	94,386
1877	106,950	93,867	5,030	5,030	......	......	111,980	98,897
1878	88,631	76,695	16,335	16,435	489	675	105,455	93,805
1879	95,623	71,353	8,791	8,791	579	720	104,993	80,864
1880	125,685	111,833	10,375	10,987	875	1,240	136,935	124,060
1881	110,303	100,284	10,310	15,025	657	1,040	121,270	116,349
1882	133,426	121,070	15,597	24,581	1,249	1,946	150,272	147,597
1883	145,448	132,834	20,242	35,557	462	837	166,152	169,228
1884	107,653	100,446	21,800	32,751	688	1,254	130,141	134,451
1885	81,887	77,898	15,140	27,730	525	787	97,552	106,415
1886	118,985	114,116	23,498	40,559	350	538	142,833	155,213
1887	112,557	106,910	19,942	39,295	225	337	132,724	146,542
1888	124,818	120,429	20	50	670	910	125,508	121,389
1889	146,204	142,850	31,495	50,862	483	692	178,182	194,404
1890	145,452	139,707	30,034	52,291	205	256	175,691	192,254
1891	143,770	140,438	27,536	41,350	5	7	171,311	181,795
1892	162,372	157,463	27,488	43,623	......	......	189,860	201,086
1893	132,131	122,556	30,061	36,706	......	......	162,192	159,262
1894	119,569	111,586	40,843	46,538	......	......	160,412	158,124
1895	133,369	125,651	56,117	67,593	......	......	189,486	193,244
1896	116,331	109,054	64,946	77,535	......	......	181,277	186,589
1897	122,984	116,665	66,222	80,485	......	......	189,206	197,150
1898	99,215	93,474	70,399	81,433	......	......	169,614	174,907
1899	104,795	99,984	96,831	108,094	*½	12	201,626	208,090
1900	......	......	......	......	......	......	188,262	201,912
1901	......	......	......	......	......	......	236,247	231,594
1902	......	......	......	......	......	......	289,600	295,215

*Exported from British Columbia.

TABLE 5.

GYPSUM.

EXPORTS OF GROUND GYPSUM.

Calendar Year.	Nova Scotia.	New Brunswick.	Ontario.	Total.
	$	$	$	$
1890	......	......	......	105
1891	......	......	......	588
1892	......	......	......	20,255
1893	......	......	......	22,132
1894	2,124	17,930	......	20,054
1895	3,364	18,827	42	22,233
1896	1,270	19,246	751	21,267
1897	1,655	5,024	84	6,763
1898	1,548	4,900	......	6,448
1899	205	7,898	20	8,123
1900	......	......	......	19,834
1901	......	......	......	15,337
1902	......	......	......	5,101

TABLE 6.

GYPSUM.

IMPORTS OF GYPSUM, ETC.

GYPSUM.

Imports.

Fiscal Year.	Crude Gypsum.		Ground Gypsum.		Plaster of Paris.	
	Tons.	Value.	Pounds.	Value.	Pounds.	Value.
1880......	1,854	$3,203	1,606,578	$ 5,948	667,676	$ 2,376
1881.......	1,731	3,442	1,544,714	4,676	574,006	2,864
1882......	2,132	3,761	759,460	2,576	751,147	4,184
1883......	1,384	3,001	1,017,905	2,579	1,448,650	7,867
1884......	....	3,416	687,432	1,936	782,920	5,226
1885......	1,353	2,354	461,400	1,177	689,521	4,809
1886	1,870	2,429	224,119	675	820,273	5,463
1887.......	1,557	2,492	13,266	73	594,146	4,342
1888.......	1,236	2,193	106,068	558	942,338	6,662
1889.......	1,360	2,472	74,390	372	1,173,996	8,513
1890......	1,050	1,928	434,400	2,136	693,435	6,004
1891.......	376	640	36,500	215	1,035,605	8,412
1892.	626	1,182	310,250	2,149	1,166,200	5,595
1893......	496	1,014	140,830	442	552,130	3,143
1894....	....	1,660	23,270	198	422,700	2,386
1895.	603	960	20,700	88	259,200	1,619
1896.......	1,045	848	64,500	198	297,000	2,000
1897.......	....	772	45,000	123	969,900	4,489
1898.......	1,147	1,742	35,700	293	329,600	2,025
1899.......	325	692	33,900	338	496,300	3,120
1900.......	77	958	6,300	69	849,100	6,492
1901.......	286	1,125	65,400	1,097	502,200	3,978
1902.......	541	1,697	*56,700	249	475,300	2,641

*Equivalent to 189 barrels.

Crude gypsum, duty free. Ground gypsum, duty 15%. Plaster of Paris, duty 12½c. per 100 lbs.

IRON.

IRON.

Iron ore.—It is estimated that 404,003 tons of iron ore were mined and shipped from Canadian mines in 1902. The output in 1901 was 313,646 tons shewing an increase in 1902 of 90,357 tons or 28·8 per cent. Increased operations at the Helen mine Michipicoten, is again responsible for the greater part of the increase. Ore.

The production by provinces is given in Table 1 following: In Nova Scotia iron ores were mined at Bridgeville, Pictou county. In Quebec, the bog ores of the counties of Champlain, St. Morice, Joliette, Nicolet, Drummond and Vaudreuil were utilized. In Ontario the Helen mine above mentioned supplied much the greater part of the output, smaller

IRON. Ore.

amounts being obtained along the line of the Kingston and Pembroke and the Central Ontario Railways. British Columbia has not as yet been a large producer of iron ore. Small quantities have been mined at Cherry Bluff, Kamloops, and on Texada Island and chiefly used for fluxing purposes in the smelting of the metalliferous ores.

Production.

TABLE 1.

IRON.

PRODUCTION OF ORE BY PROVINCES.

Calendar Year.	Nova Scotia.	Quebec.	Ontario.	British Columbia.	Total.
	Tons.	Tons.	Tons.	Tons	Tons.
1886	44,388	....	16,032	3,941	64,361
1887	43,532	13,401	16,598	2,796	76,330
1888	42,611	10,710	16,894	8,372	78,587
1889	54,161	14,533	....	15,487	84,181
1890	49,206	22,305	....	....	76,511
1891	53,649	14,380	....	950	68,979
1892	78,258	22,690	....	2,300	103,248
1893	102,201	22,076	....	1,325	125,602
1894	89,379	19,492	....	1,120	109,991
1895	83,792	17,783	....	1,222	102,797
1896	58,810	17,630	15,270	196	91,906
1897	23,400	22,436	2,770	2,099	50,705
1898	19,079	17,873	21,111	280	58,343
1899	28,000	19,420	25,126	2,071	74,617
1900	18,940	19,000	82,950	1,110	122,000
1901	18,619	15,489	272,538	7,000	313,646
1902	16,172	18,524	359,288	10,019	404,003

Nova Scotia.

TABLE 2.

IRON.

NOVA SCOTIA:—ANNUAL PRODUCTION OF ORE.

(Previous to 1886).

Calendar Year.	Tons.
1876	15,274
1877	16,879
1878	36,600
1879	29,889
1880	51,193
1881	39,843
1882	42,135
1883	52,410
1884	54,885
1885	48,129

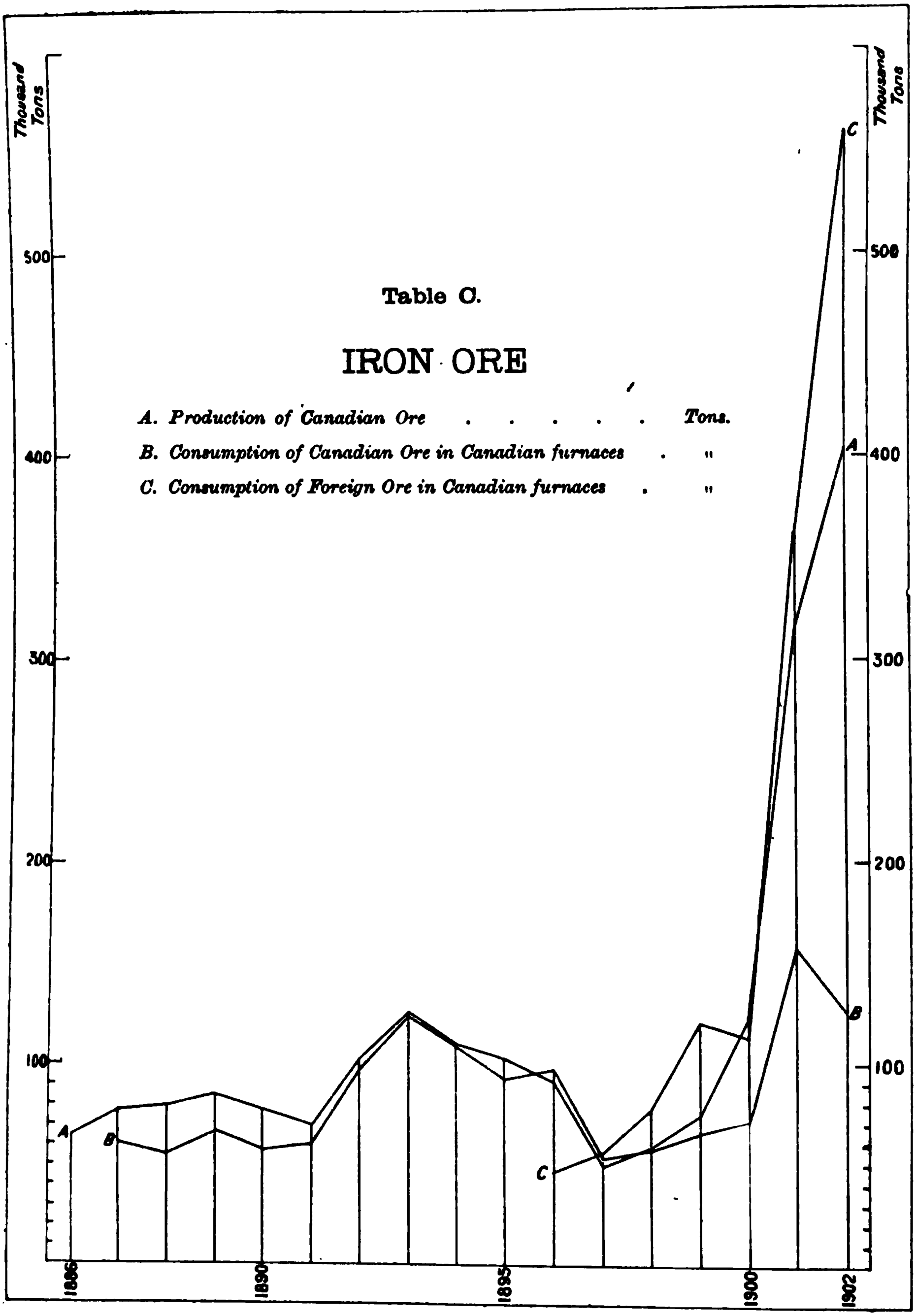


Table C.
IRON ORE
A. Production of Canadian Ore . . . . . . Tons.
B. Consumption of Canadian Ore in Canadian furnaces . "
C. Consumption of Foreign Ore in Canadian furnaces . "
Thousand Tons
500
400
300
200
100
1886
1890
1895
1900
1902
A
B
C

IRON.

The exports of iron ore from Canada, as compiled from customs reports, are shown in Tables 3 and 4 for the calendar and fiscal years respectively. In presenting these tables however attention should be called to the past two years 1901 and 1902 in which the figures appear to be too large. In 1902, for example the production for the year estimated from direct returns from mines and otherwise was 404,003 tons while the quantity of Canadian ore used in Canadian furnaces was 125,664 tons, leaving approximately 278,339 tons available for export as compared with 428,901 tons given in the table. Practically all the iron ore exported from Canada goes to the United States but for the fiscal year ending 30th June 1902, the imports of iron ore into the United States from Canada were 276,363 tons* as compared with 525,983 tons exported from Canada according to Canadian customs returns.

Exports.

TABLE 3.

IRON.

EXPORTS OF IRON ORE.

Calendar Year.	Tons.	Value.	Calendar Year.	Tons.	Value.
		$			
1893	2,419	7,590	1898	182	278
1894	....	21,294	1899	4,145	9,538
1895	1,571	3,909	1900	5,527	13,511
1896	1,033	1,911	1901	306,199	762,283
1897	403	811	1902	428,901	1,065,019

TABLE 4.

IRON.

EXPORTS OF IRON ORE.

Fiscal Year.	Tons.	Value.	Fiscal Year.	Tons.	Value.
		$			$
1879	3,562	7,530	1891	14,648	32,582
1880	30,524	76,474	1892	7,707	36,935
1881	44,677	114,850	1893	7,811	26,114
1882	43,835	135,463	1894	1,859	9,026
1883	44,914	138,775	1895	2,315	5,743
1884	25,308	66,549	1896	14	35
1885	54,367	132,074	1897	1,320	2,492
1886	7,542	23,039	1898	260	402
1887	23,345	71,934	1899	1,849	4,968
1888	13,544	39,945	1900	4,327	7,689
1889	24,752	60,289	1901	58,401	150,657
1890	13,811	31,376	1902	525,983	1,303,901

* The foreign Commerce and Navigation of the United States for the year ending 30th June, 1902.

IRON.
Pig iron production.

TABLE 5.

IRON.

PIG IRON PRODUCTION: CONSUMPTION OF ORE, FUEL, &c.

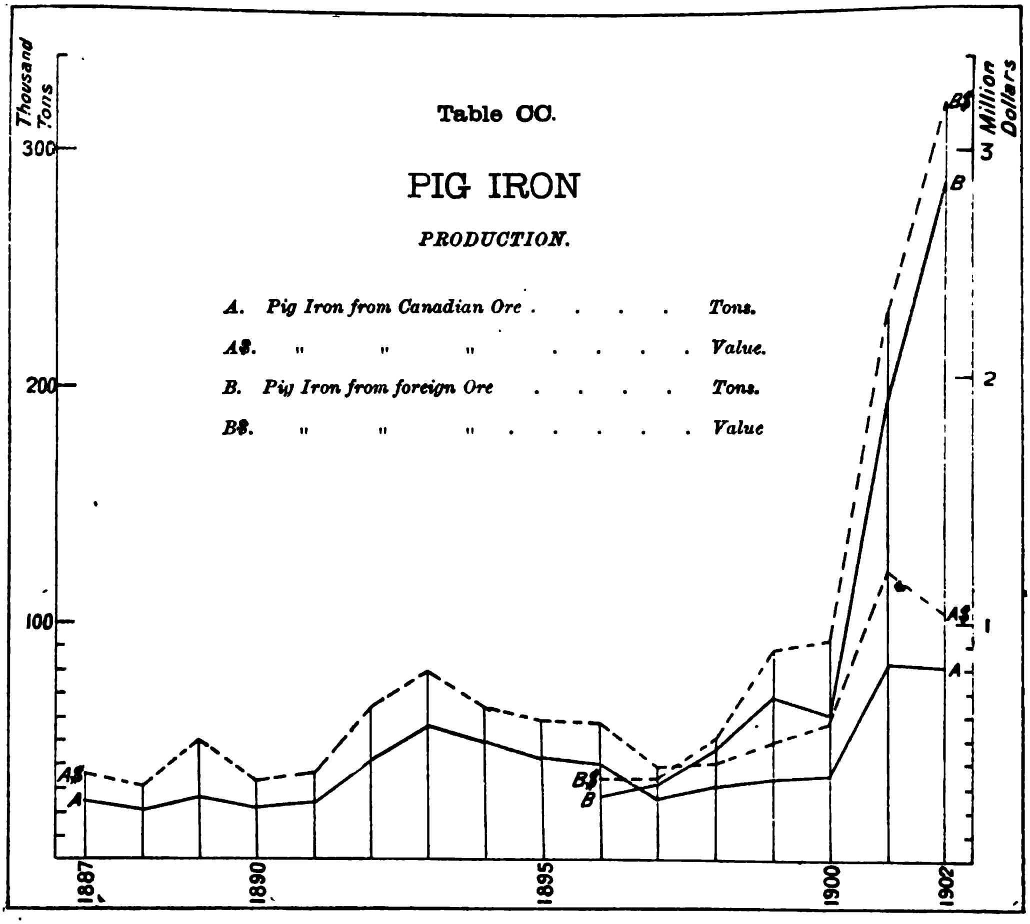
Calendar Year.	Iron Ore Consumed.		Fuel Consumed.						Flux Consumed.		Pig Iron Made.		
			Charcoal.		Coke.		Coal.						
	Tons.	Value.	Bushels.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Value per ton.
1887	60,434	$130,808	940,400	$48,593	30,248	$89,123	3,333	$5,877	17,171	$17,500	24,827	$366,192	$14 75
1888	54,956	102,343	804,286	41,800	28,031	82,986	2,197	4,709	16,857	16,533	21,799	313,235	14 37
1889	65,670	126,064	755,800	41,568	33,289	94,791	3,044	6,525	22,122	21,909	25,921	499,872	19 28
1890	57,304	117,880	589,860	29,493	32,832	97,659	1,241	2,638	18,478	18,361	21,772	331,688	15 23
1891	60,935	130,955	441,812	22,091	30,626	98,402	2,170	2,868	11,377	11,546	23,891	368,901	15 44
1892	96,945	250,966	1,121,365	78,291	50,882	152,311	1,740	1,797	22,967	21,687	42,443	637,421	15 02
1893	124,053	296,979	1,302,720	90,976	58,711	163,849	6,621	13,539	27,797	27,519	55,947	790,283	14 13
1894	108,871	223,861	1,173,970	53,958	52,373	142,303	7,653	14,571	38,101	34,347	49,967	646,447	12 94
1895	93,208	218,336	789,561	31,582	48,540	139,475	3,089	5,396	31,585	29,922	42,454	586,736	13 82
1896	(a) 96,560	200,887	756,600	32,256	(a) 48,660	106,939	1,407	2,288	37,462	36,140	67,268	924,129	13 74
	(b) 46,300	100,205			(b) 33,990	109,253							
1897	(a) 53,658	131,705	1,031,800	43,230	(a) 35,800	71,600	......	....	31,273	30,258	58,007	738,701	12 73
	(b) 55,722	138,504			(b) 27,810	94,553							
1898	(a) 57,881	151,760	836,400	41,820	(a) 31,952	63,904	......	....	33,913	31,153	77,015	912,395	11 85
	(b) 77,107	213,165			(b) 50,407	158,783							
1899	(a) 66,384	216,322	1,928,025	87,858	(a) 44,844	134,532	......	....	51,826	44,286	102,940	1,377,306	13 38
	(b) 120,650	402,860			(b) 64,648	193,944							
1900	(a) 71,341	184,191	1,799,737	82,408	(a) 45,021	180,084	......	....	52,966	39,332	96,575	1,501,698	15 55
	(b) 113,042	351,382			(b) 59,345	255,892							
1901	(a) 156,613	544,144	1,835,736	100,978	(a) 205,796	539,328	2,039	6,117	169,399	183,162	274,376	3,512,923	12 80
	(b) 361,010	846,398			(b) 115,367	497,386							
1902	(a) 125,664	429,753	2,146,623	118,275	(a) 360,593	898,518	1,615	5,006	293,594	219,295	357,902	4,243,541	11 85
	(b) 559,381	964,979			(b) 112,314	494,433							

(a) Canadian. (b) Foreign.

IRON.

Pig iron.

Pig Iron.—The total quantity of pig iron made in Canada in 1902 from both home and imported ores was 357,902 tons valued at the furnaces at $4,243,541 as compared with 274,376 tons valued at $3,512,923 in 1901, being an increase in quantity of 30 per cent, and in value of over 20 per cent. The total quantity of pig iron made in Canada in 1900 was 96,757 tons and in 1899 102,940 tons.



Statistics of the production of pig iron together with the iron ore, fuel and flux consumed are given in Table 5 for the years 1887 to 1902 inclusive. Previous to 1896 the pig iron manufactured was entirely from Canadian ores. Since that date however, increasing quantities of imported ores have been used which will be found separately stated in the table.

Attention should here be directed to a change in the statement of the production of pig iron for 1895. Owing to an error in a return received from one of the operators, the production for that year was overstated by 10,000 tons. That amount was credited to production which as a matter of fact was sold from stock. IRON. Pig iron.

Of the total output of pig iron for 1902, 339,037 tons were made with coke as fuel and 18,865 tons with charcoal.

As already mentioned, the ores used in Canadian furnaces before 1896, were derived entirely from Canadian mines. Beginning with that year however, imported ores began to be used, chiefly from the United States and Newfoundland, the imported ore in 1902 amounting to nearly 82 per cent of the total used.

In the tabulated statement showing the mineral production of Canada, the production of pig iron from Canadian ore only is given. This has been arrived at by separating the total production at each furnace into two classes, viz. pig iron from Canadian ore, and pig iron from ore imported, the separation being made on the basis of the Canadian and imported ore entering into the production of pig iron at each respective furnace.

The production for the past seven years, separated in this way has been as follows :

Calendar Year.	Pig iron from Canadian Ore.	Pig iron from Imported Ore.
	Tons.	Tons.
1896	40,720	26,548
1897	26,200	31,807
1898	30,553	46,462
1899	34,244	68,699
1900	35,387	61,188
1901	83,100	191,276
1902	71,664	286,238

There were nine furnaces in blast for varying periods during the year operated by the following six companies :

Dominion Iron and Steel Company, Sydney, C.B.
Nova Scotia Steel and Coal Company, New Glasgow, N.S.
Canada Iron Furnace Company, Montreal, Que.
John McDougall & Company, Montreal, Que.
Deseronto Iron Company, Deseronto, Ont.
Hamilton Steel and Iron Company, Hamilton, Ont.

IRON.

Pig iron.

An old furnace was being rebuilt by:

The Londonderry Iron and Mining Company, Limited, Londonderry, N.S.

New furnaces were being erected by:

The Nova Scotia Steel and Coal Company, Limited, at Sydney Mines, C.B.

The Cramp Steel Company, Limited, Collingwood, Ont.

The Algoma Steel Company, Limited, Sault Ste. Marie, Ont.

The statistics of the production of pig iron and steel and of rolled iron and steel in Canada, as well as in the United States, are admirably presented in the Annual Statistical Report of the American Iron and Steel Association, and the following information concerning the production of steel and rolled iron and steel in Canada is taken from the above mentioned report for 1902.

Steel.

Steel.—"The total production of steel ingots and castings in Canada in 1902 was 182,037 gross tons, against 26,084 tons in 1901, an increase of 155,953 tons. Bessemer and open hearth steel ingots and castings were made in each year. Almost all of the open hearth steel reported in 1902 was made by the basic process. The direct castings made in 1902 amounted to 5,288 tons.

"The following table gives the production of all kinds of steel ingots and castings in Canada from 1894 to 1902 in gross tons.

Years.	Gross tons.
1894	25,685
1895	17,000
1896	16,000
1897	18,400
1898	21,540
1899	22,000
1900	23,577
1901	26,084
1902	182,037

"The large increase in the production of steel in Canada in 1902 over 1901, was caused by the starting up of the new open hearth steel plant of the Dominion Iron and Steel Company, Limited, at Sydney, Cape Breton, Nova Scotia, which first produced steel on December 31st, 1901, and of the new Bessemer plant of the Algoma Steel Company, Limited, at Sault Ste. Marie, Ontario, at which steel was first made on

February 18, 1902. The latter company has two 6-gross-ton Bessemer converters, which were operated for a few months in 1902, producing in all 44,537 gross tons of ingots. The company also has a rail mill which first made Bessemer steel rails on May 5, 1902, and which also ran for a few months in that year, producing 32,878 tons. In addition this company produced 1,558 tons of other rolled products in 1902. The Dominion Iron and Steel Company made 99,377 tons of basic open hearth steel ingots, 48 tons of steel castings and 86,424 tons of blooms, billets and slabs. It did not make steel rails. It has ten 50-gross-ton open hearth furnaces. IRON. Steel.

"*Rolled Iron and Steel.*—The production of Bessemer and open hearth steel rails in 1902 amounted to 33,950 gross tons, against 891 tons of open hearth rails in 1901; structural shapes 423 tons against 4,388 tons in 1901; cut nails made by rolling mills and steel works having cut nail factories connected with their plants 114,685 kegs of 100 pounds, against 126,891 kegs in 1901; plates and sheets 2,191 tons against 2,857 tons in 1901; all other rolled products, excluding muck and scrap bars, blooms, billets, sheet bars &c., 119,801 tons against 98,206 tons in 1901. Changing the cut nail production to gross tons, the total quantity of all kinds of iron and steel rolled into finished forms in Canada in 1902 amounted to 161,485 tons, against 112,007 tons in 1901. Rolled iron and steel.

"The following table gives the production of all kinds of iron and steel rolled into finished forms in Canada from 1895 to 1902.

Years.	Gross Tons.
1895	66,402
1896	75,043
1897	77,021
1898	90,303
1899	110,642
1900	100,690
1901	112,007
1902	161,485

"On December 31, 1902, there were 19 completed rolling mills and steel works in Canada and one plant was being erected. Of the completed plants 2 were equipped for the manufacture of steel castings only, 4 for the manufacture of Bessemer or open hearth steel ingots and rolled products, and 13 for the manufacture of rolled products only. The plant in course of construction was being equipped for the manufacture of Bessemer and open hearth ingots and finished rolled products.

IRON.

Rolled iron and steel.

"The Canada Switch and Spring Company, limited of Montreal, has changed its name to the Montreal Steel Works, limited, and has practically discountinued the manufacture of steel castings by the Bessemer process and will hereafter make steel castings by the open hearth process only. Its Bessemer castings were produced in a 3,000 pound modified acid converter, which was first put in operation in 1897. In 1901 the company erected and put in operation, one 15-gross-ton acid open hearth furnace, and in 1903 it built another 15-ton acid furnace. Nearly all the steel castings made by the company in 1902 were produced by the open hearth process.

"The Page-Hersey Iron and Tube Company, limited, is erecting a plant at Guelph, Ontario, for the manufacture of wrought iron pipe. It is the intention of the company to add in the near future a number of puddling and busheling furnaces and 2 trains of rolls (one 12 and one 16 inch) and to manufacture skelp for use in its pipe mill. Small quantities of bar iron may also be made. The plant will have an annual capacity of about 17,000 gross tons of finished rolled material and 15,000 tons of wrought iron pipe.

"The Cramp Steel Company limited, expects to have two 18-gross ton basic-open-hearth steel furnaces and two trains of rolls (one 10 and one 18 inch) in operation at its new plant at Collingwood, Ontario, late in the spring of 1903. When completed the works will make steel rails, beams, plates, merchant bar iron, rods, shafting, &c.

"The rolling mill formerly located at Guelph, Ontario, and operated by the Guelph Iron and Steel Company, limited, was removed to London, Ontario, in the fall of 1902 and is now being operated at the latter place by the London Rolling Mill Company, limited. A 14 inch roughing mill has been added and the plant can now turn out annually about 15,000 gross tons of merchant bar iron and steel, and 6,000 tons of bolts, nuts and hinges. Operations at London were commenced in March 1903."

Bounties.

Bounties.—Bounties on iron and steel made in Canada were provided for by the Dominion Government in 1897 (chapter 6 of 60–61 Victoria, Statutes of Canada) as follows :—

	Per ton.
On steel ingots manufactured from ingredients of which not less than 50 per cent of the weight thereof consists of pig iron made in Canada	$3 00
On puddled iron bars manufactured from pig iron made in Canada	3 00
On pig iron manufactured from ore—	
On the proportion produced from Canadian ore	3 00
On the proportion produced from foreign ore	2 00

IRON.

Bounties.

It was also provided that no bounty should be paid on steel ingots made from puddled iron bars manufactured in Canada.

The Act further provided that the above mentioned bounties should cease on April 23, 1902. In 1899, an Act was passed (chapter 8 of 62–63 Victoria, Statutes of Canada, 1899), extending the time for payment of bounties to June 30, 1907, and changing the rates in a manner providing for a gradual extinguishment of the bounties.

The Act of 1899 was amended in 1903 by an act which provided for the payment of bounties on the undermentioned articles manufactured in Canada from steel produced in Canada from ingredients of which not less than fifty per cent of the weight thereof consists of pig iron made in Canada, viz. :—

	Per ton.
On rolled, round wire rods not over three-eighths of an inch in diameter, when sold to wire manufacturers for use in making wire in their own factories in Canada..........	$6 00
On rolled angles, trees, channels, beams, joists, girders, or bridge building or structural rolled sections, and on other rolled shapes not round, oval, square or flat, weighing not less than thirty-five pounds per lineal yard, and also on flat eye-bar blanks, when sold for consumption in Canada......	3 00
On rolled plates not less than thirty inches in width and not less than one-quarter of an inch in thickness, when sold for consumption in Canada for manufacturing purposes for which such plates are usually required, — not including plates to be sheared into plates of less width.....	3 00

The act of 1903 also provides for the gradual extinguishment of the bounties authorized in 1897 as follows :—

Period.	On steel ingots, puddled iron bars, and pig iron from Canadian ore.	On pig iron from foreign ore.
	Per ton.	Per ton.
From July 1, 1903 to June 30, 1904............	$ 2.70	$ 1.80
" " 1904 to June 30, 1905...........	2.25	1.50
" " 1905 to June 30, 1906............	1.65	1.10
" " 1906 to June 30, 1907	1.05	0.70

The payments by the Dominion Government on account of iron and steel bounties during the fiscal year ending June 30, 1902, were as follows, the figures having been compiled from the Auditor General's Report for 1902.

RON.

Bounties.

Bounties on Pig Iron.

Company.	On Pig Iron from Canadian Ore. Tons.	Bounties.	On Pig Iron from Imported Ore. Tons.	Bounties.	Total Bounties.
		$ c.		$ c.	$ c.
Canada Iron Furnace Co., Ltd. Midland, Ont	*a* 17,248·44 *b* 1,589·42	56,036 75	*c* 9,595,720 *d* 2,732,190	24,109 37	80,146 12
Radnor Forges, Que...	*a* 4,009·10 *b* 1,316·06	15,580 66	*c* 1,128,575 *d* 258,285	2,722 06	18,302 72
Deseronto Iron Co.....	*a* 156·00 *b* 53·00	611 10	*c* 8,920,000 *d* 2,267,000	21,920 60	22,531 70
Dom. Iron & Steel Co..	*a* 129·03 *b* 28·72	464 66	*c* 157,629,528 *d* 43,460,612	393,488 15	[1]393,952 81
Electric Reduction Co., Ltd., Bkhm.........	*a* 56·10	168 30	....	....	168 30
Hamilton Steel & Iron Co..	*a* 31,516·99 *b* 9,380·97	119,879 59	*c* 17,774,740 *d* 2,386,570	41,645 49	[2]161,525 08
John McDougall & Co., Drummondville...	*a* 702·89 *b* 340·13	3,027 02	....	....	3,027 02
N. Scotia Steel & Coal Co...............	*a* 5,135·68 *b* 1,438·40	19,290 72	*c* 17,727,320 *d* 3,672,600	42,065 32	61,356 04
	73,100·93	215,058 80	267,553,140	525,950 99	741,009 79

a Bounties paid at the rate of $3 00 per ton.
b " " 2 70 "
c " " 2 00 "
d " " 1 80 "
[1] Withheld in dispute, $46,051.76.
[2] Deducted for previous errors, $1,849 66.

Bounty on Puddled Iron Bars.

Company.	Tons.	Bounty.
		$ c.
Hamilton Steel and Iron Co	*a* 5,641·46 *b* 1,342·65	20,549 52

Bounty on Steel Ingots.

Hamilton Steel and Iron Co....................	*a* 12,858·61 *b* 3,929·99	*49,140 88
Nova Scotia Steel and Coal Co.........	*a* 16,479·14 *b* 3,123·60	†57,871 18
		107,012 06

* Withheld, $6,308.97.
† " $23,271·60.

The total amount of bounties on iron and steel paid by the Dominion Government during the fiscal year ending June, 1902, was, therefore, as follows :— IRON. Bounties.

Bounties on pig iron	$741,009 79
" puddled iron bars	20,549 52
" steel ingots	107,012 06
	$868,571 37
Less withheld in dispute and deducted for overpayment	77,481 99
Total amount paid	$791,089 38

Table 6 following illustrates the extent of the foreign trade of the country in regard to iron and steel products and machinery, &c., made therefrom. Compared with the previous year, increases are shown in all the items with the exception of machinery, hardware and scrap iron and steel.

TABLE 6.

IRON.

EXPORTS OF IRON AND STEEL GOODS, THE PRODUCT OF CANADA. Exports.

Calendar Year 1902.		Quantity.	Value.
			$
Stoves	No	776	8,742
Sewing Machines	"	1,174	24,279
Machinery, N.E.S	$	....	310,251
Hardware, N.E.S	"	....	67,108
Steel and Manufactures of	"	....	1,239,972
Castings, N.E.S	"	....	186,890
Scrap Iron and Steel	Cwt	133,822	135,463
Pig Iron	Tons	75,195	778,619
Total		....	2,751,324

The Canadian consumption of iron and steel products is illustrated in the following tables, Nos. 7, 8, 9, 10a, 10b and 11. The first three of these deal with the cruder forms of the metal, the next two with the manufactured articles wholly or largely composed of iron and steel, whilst the last table summarizes all the preceding ones. They all cover the fiscal year ending June 30, 1902.

IRON.

Imports.

TABLE 7.

IRON.

IMPORTS OF IRON, PIG, SCRAP, &c.

Fiscal Year.	Pig Iron.		Charcoal Pig Iron.		Old and Scrap Iron.		Wrought Scrap and Scrap Steel.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
		$		$		$		$
1880	(a) 23,159	371,956	....	....	928	14,042	....	....
1881	(a) 43,630	715,997	....	....	584	8,807	....	....
1882	56,594	811,221	6,837	211,791	1,327	20,406	....	....
1883	75,295	1,085,755	2,198	58,994	709	7,776	....	....
1884	49,291	653,708	2,893	66,602	3,136	44,223	....	....
1885	42,279	545,426	1,119	27,333	3,552	46,275	....	....
1886	42,463	528,483	3,185	60,086	10,151	158,100	....	....
1887	46,295	554,388	3,919	77,420	17,612	220,167	(b) 79	1,086
	Pig Iron, &c. (c)							
	Tons.	Value.						
		$						
1888	48,973	648,012	....	....	....	....	23,293	297,496
1889	72,115	864,752	....	....	....	....	26,794	335,090
1890	87,613	1,148,078	....	....	....	....	47,846	678,574
1891	81,317	1,085,929	....	....	....	....	43,967	652,842
1892	68,918	886,485	....	....	....	....	32,627	433,695
	Pig Iron.		Charcoal Pig Iron.		Cast Scrap Iron.			
	Tons.	Value.	Tons.	Value.	Tons.	Value.		
		$		$		$		
1893	56,849	682,209	5,944	84,358	729	9,317	45,459	574,809
1894	42,376	483,787	2,906	34,968	78	771	30,850	369,682
1895	(d) 31,637	341,259	2,780	31,171	643	4,347	23,390	244,388
1896	(d) 36,131	394,591	917	11,726	93	741	13,607	157,996
1897	(d) 25,766	291,788	2,936	35,373	238	1,362	7,903	93,541
1898	(d) 37,186	382,103	2,250	23,533	1,559	13,251	(e) 48,903	534,577
1899	(d) 44,261	452,911	(f) 1,955	19,123	(f) 2,378	22,594	(e) 28,352	301,268
1900	(d) 49,767	811,490	(f) 1,816	38,736	(f) 13,747	150,681	(e) 38,753	638,505
1901	(d) 35,293	548,033	(f) 490	7,121	(f) 4,499	51,032	(e) 24,773	242,189
1902	39,978	585,077	(f) 38	726	(f) 3,048	38,958	(e) 36,150	520,909

(a) Comprises pig-iron of all kinds.

(b) From May 13 only.

(c) These figures appear in Customs reports under heading 'Iron in pigs, Iron kentledge and cast scrap-iron.'

(d) Includes iron kentledge. Duty $2.50 per ton.

(e) Scrap iron and scrap steel, old, and fit only to be remanufactured, being part of, or recovered from, any vessel wrecked in waters subject to the jurisdiction of Canada. Duty free.

Iron or steel scrap, wrought, being waste or refuse, including punchings, cuttings and clippings of iron or steel plates or sheets, having been in actual use, crop ends of tin plate bars, blooms and rails, the same not having been in actual use. Duty $1 per ton.

(f) Duty $2.50 per ton.

IRON.

Imports.

TABLE 8.

IRON.

IMPORTS OF FERRO-MANGANESE, &C.

Fiscal Year.	Tons.	Value.
*1887	123	$ 1,435
*1888	1,883	29,812
*1889	5,868	72,108
*1890	696	18,895
*1891	2,707	40,711
*1892	1,311	23,930
*1893	529	15,858
*1894	284	9,885
†1895	164	5,408
†1896	652	12,811
†1897	426	9,233
†1898	1,418	22,516
†1899	1,160	22,539
†1900	1,149	39,064
†1901	1,512	38,954
†1902 (Duty, 5 p.c.)	6,513	150,977

*These amounts include :—Ferro-manganese, ferro-silicon, spiegel, steel bloom ends, and crop ends of steel rails, for the manufacture of iron or steel.

†Ferro-silicon, spiegeleisen and ferro-manganese.

TABLE 9.

IRON.

IMPORTS : IRON IN SLABS, BLOOMS, LOOPS AND PUDDLED BARS, &C.

Fiscal Year.	Cwt.	Value.	Fiscal Year.	Cwt.	Value.
1880	195,572	$244,601	1892	64,397	56,186
1881	111,666	111,374	1893	65,269	58,533
1882	203,888	222,056	1894	50,891	45,018
1883	258,639	269,818	1895	78,639	67,321
1884	252,310	264,045	1896	128,535	110,757
1885	312,329	287,734	1897	56,560	48,954
1886	273,316	248,461	1898	162,891	122,426
1887	522,853	421,598	1899	124,311	103,198
1888	110,279	93,377	1900	255,145	362,463
1889	80,383	67,181	1901	234,925	206,975
1890	15,041	45,923	1902*	401,306	419,543
1891	41,567	38,931			

*Iron or steel ingots, cogged ingots, blooms, slabs, billets, puddled bars, and loops or other forms, N.O.P., less finished than iron or steel bars, but more advanced than pig-iron, except castings. Duty $2 per ton.

IRON.

Imports.

TABLE 10a.

IRON.

IMPORTS OF IRON AND STEEL GOODS.—1901-1902.

Fiscal Year, 1902.		Duty.	Quantity.	Value.
				$
Bar iron or steel rolled, whether in coils, bundles, rods or bars, comprising rounds, ovals, squares and flats and rolled shapes, N.O.P.	Cwt.	$7 per ton.	525,114	946,836
Castings, iron or steel, in the rough, N.E.S.	$	25 %	....	198,074
Canada plates, Russia iron, flat galvanized iron or steel sheets, terne plates and rolled sheets of iron or steel coated with zinc, spelter or other metal, of all widths or thicknesses, N.O.P.	Cwt.	5 "	466,464	1,214,045
Iron or steel bridges or parts thereof, iron or steel structural work, columns, shapes or sections drilled, punched, or in any further stage of manufacture than as rolled or cast, N.E.S	"	35 "	46,841	108,402
Malleable iron castings and iron or steel castings, N.E.S	"	25 "	1,411	5,511
Mould boards, or shares or plough plates land sides and other plates for agricultural implements, cut to shape from rolled plates of steel but not moulded, punched, or otherwise manufactured	"	5 "	46,721	178,704
Iron or steel railway bars or rails of any form, punched or not punched, N.E.S., for railways, which term for the purposes of this item shall include all kinds of railways, street railways and tramways, even although the same are used for private purposes only, and even although they are not used or intended to be used in connection with the business of common carrying of goods or passengers	Tons.	30 "	8,285	206,908
Railway fish-plates and tie plates	"	$8 per ton.	4,094	122,840
Rolled iron or steel angles, tees, beams, channels, joists, girders, zees, stars or rolled shapes, or trough, bridge, building, or structural rolled sections, or shapes not punched, drilled or further manufactured than rolled, N.E.S., and flat eye-bar blanks not punched or drilled	Cwt.	10 "	560,233	789,644
Rolled iron or steel hoop, band, scroll or strip, 8 inches or less in width, No. 18 gauge and thicker, N.E.S	"	$7 per ton.	36,296	68,541
Rolled iron or steel hoop, band, scroll or strip, thinner than No. 18 gauge, N.E.S.	"	5 %	40,782	94,114
Rolled iron or steel angles, tees, beams, channels, girders and other rolled shapes or sections, weighing less than 35 lbs. per lineal yard, not punched, drilled or further manufactured than rolled, N.O.P.	"	$7 per ton.	250,540	356,237
Rolled iron or steel plates or sheets, sheared or unsheared, and skelp iron or steel, sheared or rolled in grooves, N.E.S.	"	$7 "	216,030	333,892
Rolled iron or steel plates, not less than 30 inches in width and not less than ¼ inch in thickness, N.O.P.	"	10 "	390,008	571,291
Carried forward		....	....	5,195,039

IRON.

Imports.

TABLE 10a—*Continued.*

IRON.

IMPORTS OF IRON AND STEEL GOODS.

Fiscal Year, 1902.	Duty.	Quantity.	Value.
			$
Brought forward	....	....	5,195,039
Rolled iron or steel sheets No. 17 gauge and thinner, N.O.P. ..... Cwt.	5 p. c.	243,430	619,759
Rolls of chilled iron or steel ..... "	30 "	2,126	7,591
Skelp iron or steel, sheared or rolled in grooves, imported by manufacturers of wrought iron or steel pipe for use only in the manufacture of wrought iron or steel pipe in their own factories ..... "	5 "	323,915	496,130
Swedish rolled iron and Swedish rolled steel nail rods under half an inch in diameter for the manufacture of horse-shoe nails.. "	15 "	13,900	27,300
Switches, frogs, crossings and intersections for railways ..... "	30 "	7,037	20,221
Steel—chrome steel ..... "	15 "	4,217	35,218
Steel plate, universal mill or rolled edge bridge plates imported by manufacturers of bridges ..... "	10 "	71,861	101,682
Steel in bars, bands, hoops, scroll or strips, sheets or plates, of any size, thickness or width when of greater value than 2½c. per lb., N.O.P. ..... "	5 "	135,496	594,766
Hoop iron not exceeding ⅝ of an inch in width and being No. 25 gauge and thinner, used for the manufacture of tubular rivets "	Free.	110	308
Iron or steel beams, sheets, plates, angles, knees and cable chains for wooden, iron, steel, or composite ships or vessels ..... "	"	35,735	70,707
Locomotive and car wheel tires of steel, in the rough ..... "	"	36,388	79,045
Steel for saws and straw cutters cut to shape, but not further manufactured ..... "	"	13,365	111,261
Crucible sheet steel, 11 to 16 gauge, 2½ to 18 inches wide, imported by manufacturers of mower and reaper knives for manufacture of such knives in their own factories ..... "	"	6,886	30,360
Steel of No. 20 gauge and thinner, but not thinner than No. 30 gauge, for the manufacture of corset steels, clock springs and shoe shanks imported by the manufacturers of such articles for the exclusive use in the manufacture thereof in their own factories ..... "	"	1,788	6,643
Steel valued at 2½ cents per lb. and upward, imported by the manufacturers of skates, for use exclusively in the manufacture thereof in their own factories ..... "	"	2,058	9,921
Steel, under ½-inch in diameter, or under ½ inch square, imported by the manufacturers of cutlery, or of knobs, or of locks, for use exclusively in the manufacture of such articles in their own factories ..... "	Free.	4,020	8,783
Carried forward	....	....	7,414,734

IRON.

Imports.

TABLE 10a—*Concluded.*

IRON.

IMPORTS OF IRON AND STEEL GOODS.

Fiscal Year, 1902.	Duty.	Quantity.	Value.
			$
Brought forward..................	....	.. ..	7,414,734
Steel, No. 12 gauge and thinner, but not thinner than No. 30 gauge, for the manufacture of buckle clasps, bed fasts, furniture casters and ice creepers, imported by the manufacturers of such articles, for use exclusively in the manufacture thereof in their own factories... .... Cwt.	"	825	2,614
Steel of No. 24 and 17 gauge, in sheets sixty-three inches long, and from 18 inches to 32 inches wide, imported by the manufacturers of tubular bow sockets for use in the manufacture of such articles in their own factories........................ "	"	2,258	7,483
Steel for the manufacture of bicycle chains, imported by the manufacturers of bicycle chain for use in the manufacture thereof in their own factories.. .... "	"	267	1,060
Steel for the manufacture of files, augers, auger bits, hammers, axes, hatchets, scythes, reaping hooks, hoes, hand rakes, hay or straw knives, windmills and agricultural or harvesting forks imported by the manufacturers of such or any of such articles for use exclusively in the manufacture thereof in their own factories ... "	"	66,114	153,114
Steel springs for the manufacture of surgical trusses imported by the manufacturers for use exclusively in the manufacture thereof in their own factories..... . .. "	"	245	3,923
Flat spring steel, steel billets and steel axle bars, imported by manufacturers of carriage springs and carriage axles for use exclusively in the manufacture of springs and axles for carriages or vehicles other than railway or tramway, in their own factories .. .. "	"	73.624	119,309
Spiral spring steel for spiral springs for railways, imported by the manufacturers of railway spring for use exclusively in the manufacture of railway spiral springs in their own factories .... "	"	34,047	61,671
Malleable iron or steel castings, in the rough for the manufacture of scissors, and hand shears when imported by manufacturers of scissors and hand shears to be used in making such articles in their own factories, O.C.......... .... $	"	....	2,394
Steel for the manufacture of cutlery when imported by manufacturers of cutlery to be used in their own factories in the manufacture of such article, O.C........ Cwt.	"	757	2.030
Total	....	....	7,768,332

TABLE 10*b*.

IRON.

IMPORTS OF IRON AND STEEL GOODS.

IRON.

Imports.

Fiscal Year, 1902.		Duty.	Quantity.	Value.
				$
Agricultural implements, N.E.S., viz:				
Binding attachments	No.	20 %	103	9,991
Cultivators	"	20 "	2,755	22,863
Drills, grain seed	"	20 "	2,012	50,092
Farm, road or field rollers	"	25 "	216	3,127
Forks, pronged	"	25 "	13,930	7,816
Harrows	"	20 "	2,470	36,730
Harvesters, self binding and without binders	"	20 "	9,288	900,179
Hay tedders	"	25 "	115	3,028
Hoes	"	25 "	3,406	1,010
Horse rakes	"	20 "	9,741	180,658
Knives, hay or straw	"	25 "	446	246
Lawn mowers	"	35 "	1,193	6,466
Manure spreaders	"	20 "	91	2,356
Mowing machines	"	20 "	17,643	599,050
Ploughs	"	20 "	10,092	214,193
Post hole diggers	"	25 "	541	489
Potato diggers	"	25 "	118	1,780
Rakes, N.E.S	"	25 "	5,028	1,139
Reapers	"	20 "	755	36,329
Scythes and snaths, sickles or reaping hooks	Doz.	25 "	2,952	11,970
Spades and shovels and spade and shovel blanks, and iron or steel cut to shape for the same	"	35 "	5,407	28,993
Parts of agricultural implements	$	20 "	....	489,827
All other agricultural implements, N.E.S.	$	25 "	....	47,136
Anvils and vises	"	30 "	....	27,621
Cart or wagon skeins or boxes	Lbs.	30 "	38,806	2,459
Springs, axles, axle bars, N. E. S., and axle blanks and parts thereof of iron or steel, for railway or tramway or other vehicles	Cwt.	35 "	40,937	107,442
Butts and hinges, N.E.S.	$	30 "	....	29,220
Cast iron pipe of every description	Cwt.	$8 per ton	29,463	44,691
Chains, coil chains, chain links and chain shackles of iron or steel 5-16 of an inch in diameter and over	"	5 %	37,487	138,349
Chain, malleable sprocket or link belting, for binders	$	20 "	....	14,462
Chains, N.E.S	"	30 "	....	62,221
Tacks, shoe	Lbs.	35 "	51,815	3,882
Cut tacks, brad sprigs, or shoe nails, double pointed, and other tacks of iron and steel, N.O.P.	"	35 "	154,070	11,188
Engines, locomotives for railways, N.E.S.	No.	35 "	80	611,925
Fire engines	"	35 "	4	2,376
Fire extinguishing machines	"	35 "	25,968	19,327
Steam engines and boilers	"	25 "	849	382,022
Fittings, iron or steel, for iron and steel pipe	Lbs.	30 "	3,898,368	232,428
Carried forward		....	....	4,345,081

IRON.

Imports.

TABLE 10b—*Continued.*

IRON.

IMPORTS OF IRON AND STEEL GOODS.

Fiscal Year, 1902.		Duty.	Quantity.	Value.
				$
Brought forward		....	....	4,345,081
Forgings of iron or steel, of whatever shape or size, or in whatever stage of manufacture, N.E.S., and steel shafting, turned, compressed or polished, and hammered iron or steel bars or shapes, N.O.P.	Lbs.	30 %	2,801,773	93,272
Hardware, viz:				
Builders', cabinet-makers', upholsterers', harness-makers', saddlers' and carriage hardware, including currycombs and horse boots, N.E.S.	$	30 "	....	653,361
Horse, mule and ox shoes	"	30 "	....	5,796
Locks of all kinds	"	30 "	....	146,889
Machines and machinery, &c.:				
Fanning mills	No.	25 "	271	4,555
Grain crushers	"	25 "	43	1,619
Windmills	"	25 "	483	20,373
Ore crushers and rock crushers, stamp mills, cornish and belted rolls, rock drills, air compressors, cranes, derricks and percussion coal cutters	$	25 "	....	52,527
Portable machines:				
Fodder or feed cutters	No.	25 "	16	60
Horse powers	"	25 "	62	6,590
Portable engines	"	25 "	271	261,188
Portable saw mills and planing mills	"	25 "	7	5,163
Threshers and separators	"	25 "	678	147,634
All other portable machines	"	25 "	889	49,691
Parts of above articles	$	25 "	....	122,647
Sewing machines and parts of	No.	30 "	12,819	246,400
Slot machines	"	25 "	448	8,030
Machines, type-writing	"	25 "	2,402	129,949
All other machinery composed wholly or in part of iron or steel, N.O.P.	$	25 "	....	3,468,923
Nails and spikes, composition and sheathing nails	Lbs.	15 "	44,313	7,118
Nails and spikes, wrought and pressed, trunk, clout, coopers, cigar box, Hungarian horseshoe and other nails, N.E.S.	"	30 "	170,310	9,516
Nails and spikes, cut, and railway spikes	"	½c. per lb.	1,457,275	32,725
Nails, wire of all kinds, N.O.P.	"	⅜c. "	372,591	12,862
Pumps, N.E.S.	$	25 %	....	187,285
Safes, doors for safes and vaults	"	30 "	....	21,330
Screws, iron and steel, commonly called "woodscrews," N.E.S.	Lbs.	35 "	119,835	14,124
Scales, balances, weighing beams and strength testing machines	$	30 "	....	102,692
Skates of all kinds and parts thereof	Pairs	35 "	50,896	19,105
Stoves of all kinds and parts thereof, N.E.S.	$	25 "	....	172,791
Stove plates, and sad or smoothing, hatters' and tailors' irons, plated wholly or in part or not	"	25 "	....	10,215
Carried forward		....	... .	10,359,511

IRON.

Imports.

TABLE 10b—*Continued.*

IRON.

IMPORTS OF IRON AND STEEL GOODS.

Fiscal Year, 1902.		Duty.	Quantity.	Value.
Brought forward				10,359,511
Sheet iron or steel corrugated, galvanized	Cwt.	25 "	1,693	5,696
Sheet iron or steel corrugated not galvanized	"	30 "	12,104	17,053
Tubing:				
Boiler tubes of wrought iron or steel, including flues and corrugated tubes for marine boilers	Lbs.	5 %	8,628,283	324,042
Tubes of rolled steel, seamless, not joined or welded, not more than 1½ inches in diameter	"	10 "	164,313	8,475
Tubes, seamless steel, for bicycles	"	10 "	227,275	16,550
Tubing, wrought iron or steel, plain or galvanized, threaded and coupled or not, over 2 inches in diameter, N.E.S.	"	15 "	8,794,898	281,140
Tubing, wrought iron or steel, plain or galvanized, threaded and coupled or not, 2 inches or less in diameter, N.E.S.	"	35 "	3,308,697	107,395
Other iron or steel tubes or pipes, N.O.P.	"	30 "	347,575	24,309
Ware, galvanized sheet iron or of galvanized sheet steel, manufactures of, N.O.P.	$	25 "		23,827
Ware, agate, granite or enamelled iron or steel hollow ware	"	35 "		28,714
Ware, enamelled iron or steel ware, N.E.S., iron or steel hollow ware, plain black, tinned or coated, and nickel and aluminium kitchen or household hollow ware, N.E.S	"	30 "		101,147
Wire cloth or wove wire and netting of iron or steel	Lbs.	30 "	710,944	31,713
Wire screens, doors and windows	$	30 "		10,660
Wire fencing, woven, buckthorn strip and wire fencing of iron or steel, N.E.S.	Lbs.	15 "	385,670	13,825
Wire, single or several, covered with cotton, linen, silk, rubber or other material, &c., N.E.S	"	30 "	2,269,407	315,706
Wire of all kinds, N.O.P	"	20 "	7,051,024	190,422
Wire rope, stranded or twisted wire, clothes lines, picture or other twisted wire and wire cables, N.E.S.	"	25 "	1,612,206	130,565
Iron or steel nuts, washers, rivets and bolts with or without threads and nut bolt and hinge blanks, and T. and strap hinges of all kinds, N.E.S	"	¾ c.p. lb. and 25 %	2,289,930	92,031
Pen-knives, jack-knives and pocket knives of all kinds	$	30 %		107,109
Table cutlery, all kinds, N.O.P	"	30 "		214,076
All other cutlery, N.E.S	"	30 "		206,502
Guns, rifles, including air guns and air rifles, (not being toys) muskets, cannons, pistols, revolvers, or other firearms	"	30 "		257,135
Bayonets, swords, fencing foils and masks	"	30 "		2,716
Needles of any material or kind, N.O.P.	"	30 "		58,553
Carried forward				12,928,872

IRON.

Imports.

TABLE 10b—*Continued.*

IRON.

IMPORTS OF IRON AND STEEL GOODS.

Fiscal Year, 1902.		Duty.	Quantity.	Value.
				$
Brought forward		... .	....	12,928,872
Tools and implements :				
Adzes, cleavers, hatchets, wedges, sledges, hammers, crow bars, cant dogs and track tools, picks, mattocks and eyes or poles for the same	$	30 %	......	29,041
Axes	Doz.	25 "	10,379	50,148
Saws	$	30 "	....	120,323
Files and rasps, N.E.S.	"	30 "	....	93,668
Tools, hand or machine, of all kinds, N.O.P	"	30 "	....	603,190
Knife blades, or blanks, and forks of iron or steel, in the rough not handled, filed, ground or otherwise manufactured	"	10 "	....	452
Manufactured articles or wares not specially enumerated or provided for, composed wholly or in part of iron or steel, and whether partly or wholly manufactured	"	30 "	....	1,434,062
Anchors	Cwt.	Free	5,372	19,766
Iron or steel, rolled round wire rods, in the coil not over ⅜-inch in diameter, imported by wire manufacturers for use in making wire in the coil in their factories	"	"	1,103,641	1,522,792
Iron or steel masts, or parts of	"	"	29	380
Rolled iron tubes not welded, or joined, under 1½ inch in diameter, angle iron 9 and 10 gauge, not over 1½ inch wide, iron tubing lacquered or brass covered, not over 1½ inch diameter, all of which are to be cut to lengths for the manufacture of bedsteads, and to be used for no other purpose, and brass trimmings for bedsteads imported for the manufacture of iron or brass bedsteads	"	"	29,023	96,309
Steel bowls for cream separators and cream separators	$	"	....	487,834
Steel rails weighing not less than 45 lbs. per lineal yard for use only in the tracks of railways which are employed in the common carrying of goods and passengers, and are operated by steam motive power only	Cwt.	"	2,447,356	2,746,222
Steel strip and flat steel wire imported by manufacturers of buckthorn and plain strip fencing, for use in their own factories in the manufacture thereof	"	"	7,900	10,554
Steel wire, Bessemer soft drawn spring of Nos. 10, 12 and 13 gauge respectively, and homo steel spring wire of Nos. 11 and 12 gauge, respectively, imported by manufacturers of wire mattresses, to be used in their own factories in the manufacture of such articles	"	"	4,015	11,561
Carried forward		....	....	20,156,174

IRON.

Imports.

TABLE 10b—*Concluded.*

IRON.

IMPORTS OF IRON AND STEEL GOODS.

Fiscal Year, 1902.		Duty.	Quantity.	Value.
				$
Brought forward		....	....	20,156,174
Machinery and structural iron for beet root sugar factories	$	Free.	....	655,781
Flat steel wire of No. 16 gauge or thinner imported by the manufacturers of crinoline, corset wire and dress stays, for use in the manufacture of such articles in their own factories	Cwt.	"	5,351	19,138
Wire, crucible cast steel	Lbs.	"	1,166,422	88,377
Galvanized iron or steel wire Nos. 9, 12 and 13 gauge	Cwt.	"	297,084	548,185
Barbed fencing wire of iron and steel	"	"	329,391	826,846
Total		....	....	22,294,501

TABLE 11.

IRON.

IMPORTS OF PIG IRON, IRON AND STEEL GOODS, &C., FISCAL YEAR, 1901-1902.

Recapitulation of Tables, 7, 8, 9, 10a and 10b.

——	Tons.	Value.
Pig iron and iron kentledge	39,978	$ 585,077
Pig iron, charcoal	38	726
Scrap iron, cast	3,048	38,958
Scrap steel, wrought	36,150	520,909
Ferro-manganese, &c	6,513	150,977
Iron in slabs, blooms, puddled bars, &c	20,065	419,543
Iron and steel goods partially manufactured	....	7,768,332
Iron and steel goods more highly manufactured*	....	22,294,501
Total	....	$31,779,023

*Machinery, &c., classed under iron and steel goods in Customs report.

LEAD.

LEAD.

The production of lead in Canada in 1902, was 22,956,381 pounds valued at $934,095, or an average of 4·069 cents per pound, the average monthly price for refined lead in the New York market for the year. Compared with the previous year the output for 1902 shows a decrease of over 55 per cent in quantity and a little more than one third the production in 1900. Ninety eight per cent of the production in 1902 was mined in the province of British Columbia and the falling off in output is due very largely to the suspension of operations in the East Kootenay lead mines. The average price for the year was less by over 6 per cent than in 1901.

Production.

TABLE 1.

LEAD.

ANNUAL PRODUCTION.

Calendar Year.	Pounds.	Price per Pound.	Value.
		cts.	
1887	204,800	4·50	$ 9,216
1888	674,500	4·42	29,812
1889	165,100	3·93	6,488
1890	105,000	4·48	4,704
1891	88,665	4·35	3,857
1892	808,420	4·09	33,064
1893	2,135,023	3·73	79,636
1894	5,703,222	3.29	187,636
1895	16,461,794	3·23	531,716
1896	24,199,977	2·98	721,159
1897	39,018,219	3.58	1,396,853
1898	31,915,319	3·78	1,206,399
1899	21,862,436	4·47	977,250
1900	63,169,821	4·37	2,760,521
1901	51,900,958	4·334	2,249,387
1902	22,956,381	4·069	934,095

In 1901 the Dominion Parliament passed an act providing for the payment of bounties on lead refined in Canada from materials produced in Canadian smelters from Canadian lead ores. This Act however has been repealed during the present session (1903) and is replaced by another providing for the payment of bounties on lead contained in lead-bearing ores mined in Canada.

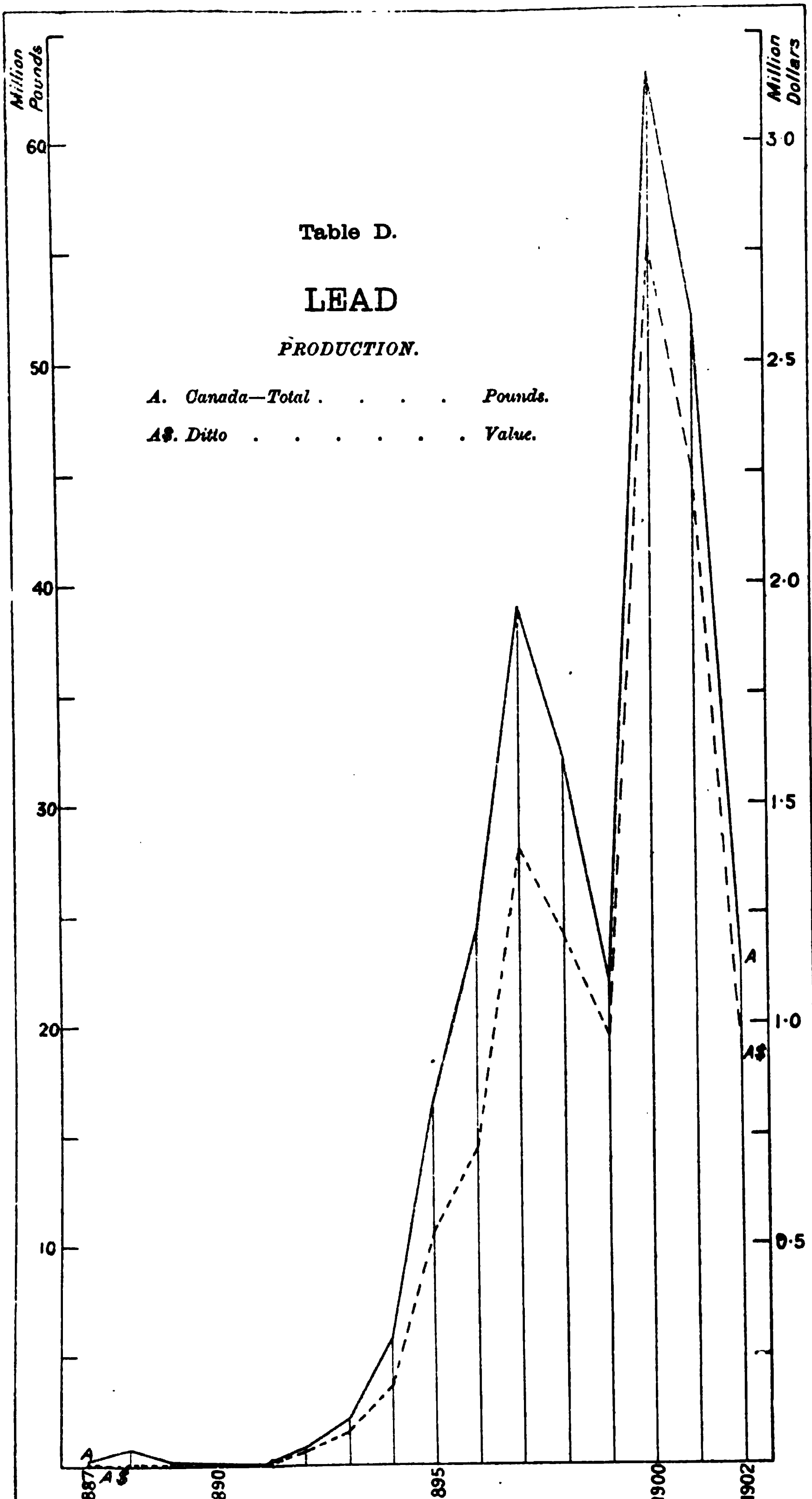


Table D.
LEAD
PRODUCTION.
A. Canada—Total . . . . Pounds.
A$. Ditto . . . . . . Value.
Million Pounds
Million Dollars
60
50
40
30
20
10
3·0
2·5
2·0
1·5
1·0
0·5
A
A$
1887
1890
1895
1900
1902

LEAD.

The new bill is as follows:

Bill.

No. 239] BILL. [1903.

An Act to provide for the payment of bounties on lead contained in lead-bearing ores mined in Canada.

His Majesty, by and with the advice and consent of the Senate and House of Commons of Canada, enacts as follows:—

Bounties on lead refined in Canada.

1. The Governor in Council may authorize the payment of a bounty of seventy five cents per one hundred pounds on lead contained in lead bearing ores mined in Canada, such bounty to be paid to the producer or vendor of such ores: Provided that, the sum to be paid as such bounty shall not exceed five hundred thousand dollars in any fiscal year: Provided also, that when it appears to the satisfaction of the minister charged with the administration of this act that the standard price of pig lead in London, England, exceeds twelve pounds ten shillings sterling per ton of two thousand two hundred and forty pounds such bounty shall be reduced proportionately by the amount of such excess.

Limitation.

Reduction if price of pig lead rises.

Mode of payment.

2. Payment of the said bounty may be made from time to time to the extent of sixty per cent upon smelter returns showing that the ore has been delivered for smelting at a smelter in Canada. The remaining forty per cent may be paid at the close of the fiscal year, upon evidence that all such ore has been smelted in Canada.

Reduction of rate if production excessive.

2. If at the close of any year it appears that during the year the quantity of lead produced, on which the bounty is authorized, exceeds thirty-three thousand three hundred and thirty-three tons of two thousand pounds, the rate of bounty shall be reduced to such sum as will bring the payments for the year within the limit mentioned in section 1.

Bounty in certain cases on lead in ore exported.

3. If at any time it appears to the satisfaction of the Governor in Council that the charges for transportation and treatment of lead ores in Canada are excessive, or that there is any discrimination which prevents the smelting of such ores in Canada on fair and reasonable terms, the Governor in Council may authorize the payment of

LEAD.

Bill.

bounty at such reduced rate as he deems just, on the lead contained in such ores mined in Canada and exported for treatment abroad.

Bounty when ore is not smelted.

4. If at any time it appears to the satisfaction of the Governor in Council that products of lead are manufactured in Canada direct from lead ores mined in Canada without the intervention of the smelting process, the Governor in Council may make such provision as he deems equitable to extend the benefits of this act to the producers of such ores.

Duration of Act.

5. The said bounties shall cease and determine on the thirtieth day of June, one thousand nine hundred and eight.

Regulations.

6. The Governor in Council may make regulations for carrying out the intentions of this Act.

Repeal of 1901, c. 8.

7. Chapter 8 of the Statutes of 1901, intituled *An act to provide for the payment of bounties on lead refined in Canada*, is repealed.

The value of the exports of lead in ore, etc., is shown in Table 2, while the imports are given in Tables 3 and 4, and of litharge in Table 5. Imports of dry white and red lead are shown in Table 6. In the latter table since 1890, the imports of zinc white have been included with the lead oxides.

TABLE 2.

LEAD.

EXPORTS.

Exports.

Calendar Year.	Value.	Calendar Year.	Value.
1873	$1,993	1888	18
1874	127	1889	....
1875	7,510	1890	....
1876	66	1891	5,000
1877	720	1892	2,509
1878	....	1893	3,099
1879	230	1894	144,509
1880		1895	435,071
1881	....	1896	462,095
1882	32	1897	925,144
1883	5	1898	885,485
1884	36	1899	466,950
1885	....	1900	1,917,690
1886	....	1901	1,804,687
1887	724	1902	457,170

LEAD.

Imports.

TABLE 3.

LEAD.

IMPORTS OF LEAD.

Fiscal Year.	Old, Scrap and Pig.		Bars, Blocks, Sheets.		Total.	
	Cwt.	Value.	Cwt.	Value.	Cwt.	Value.
1880	....	....	....	....	30,298	$124,117
1881	16,236	$ 56,919	18,222	$70,744	34,458	127,663
1882	36,655	120,870	10,540	35,728	47,195	156,598
1883	48,780	148,759	8,591	28,785	57,371	177,544
1884	39,409	103,413	9,704	28,458	49,113	131,871
1885	36,106	87,038	9,362	24,396	45,468	111,434
1886	39,945	110,947	9,793	28,948	49,738	139,895
1887	61,160	173,477	14,153	41,746	75,313	215,223
1888	68,678	196,845	14,957	45,900	83,635	242,745
1889	74,223	213,132	14,173	43,482	88,396	256,614
1890	101,197	283,096	19,083	59,484	120,280	342,580
1891	86,382	243,033	15,646	48,220	102,028	291,253
1892	97,375	254,384	11,299	32,368	108,674	286,752
1893	94,485	215,521	12,403	32,286	106,888	247,807
1894	70,223	149,440	8,486	20,451	78,709	169,891
1895	67,261	139,290	6,739	16,315	74,000	155,605
1896	72,433	173,162	8,575	23,169	81,008	196,331
1897	65,279	158,381	10,516	29,175	75,795	187,556
	Old, Scrap, Pig and Block.*		Bars and Sheets.†		Total.	
1898	88,420	$260,779	22,214	$39,041	110,634	$299,820
1899	114,659	283,432	44,796	39,833	159,455	323,265
1900	62,361	207,819	15,493	53,506	77,854	251,325
1901	(a)85,321	97,011	16,295	78,316	101,616	175,327
1902	(a)122,279	104,672	18,596	49,261	140,875	153,933

* Duty 15 p. c.

† Duty 25 p. c.

(a) Includes Canadian lead ore sent to the United States for refining, imported at price of refining only.

LEAD.
Imports.

TABLE 4.

LEAD.

IMPORTS OF LEAD MANUFACTURES.

Fiscal Year.	Value.	Fiscal Year.	Value.
1880	$15,400	1891	23,893
1881	22,629	1892	22,636
1882	17,282	1893	33,783
1883	25,556	1894	29,361
1884	31,361	1895	38,015
1885	36,340	1896	50,722
1886	33,078	1897	60,735
1887	19,140	1898	63,179
1888	18,816	1899	91,497
1889	16,315	1900	104,736
1890	25,600	1901	107,260

		Duty.	
1902	Lead Tea	Free.	$59,947
	" Pipe	35 p. c.	8,018
	" Shot and bullets	35 "	3,760
	" Manufactures, N.E.S.	30 "	48,295
	Total		$120,020

TABLE 5.

LEAD.

IMPORTS OF LITHARGE.

Fiscal Year.	Cwt.	Value.	Fiscal Year.	Cwt.	Value.
1880	3,041	$14,334	1892	10,384	34,343
1881	6,126	22,129	1893	7,685	24,401
1882	4,900	16,651	1894	38,547	28,685
1883	1,532	6,173	1895	11,955	32,953
1884	5,235	18,132	1896	10,710	32,817
1885	4,990	16,156	1897	12,028	34,538
1886	4,928	16,003	1898	11,446	32,904
1887	6,397	21,865	1899	9,530	32,518
1888	7,010	23,808	1900	9,139	29,176
1889	8,089	31,082	1901	11,132	51,944
1890	9,453	31,401	1902....Duty free	13,002	47,021
1891	7,979	27,613			

LEAD.

Imports.

TABLE 6.

LEAD.

IMPORTS OF DRY WHITE AND RED LEAD AND ORANGE MINERAL.

Fiscal Year.	Pounds.	Value.
		$
1885	5,404,758	198,913
1886	6,703,077	213,258
1887	6,998,820	233,725
1888	6,361,334	216,654
1889	7,066,465	267,236

IMPORTS OF DRY WHITE AND RED LEAD, ORANGE MINERAL AND ZINC WHITE.

Fiscal Year.	Pounds.	Value.
		$
1890	10,859,672	381,959
1891	8,560,615	337,407
1892	10,288,766	351,686
1893	10,865,183	364,680
1894	10,958,170	353,053
1895	8,780,052	282,353
1896	11,711,496	367,569
1897	10,310,468	347,539
1898	12,682,808	448,659
1899	14,507,945	514,842
1900	14,679,920	634,492
1901	10,241,601	461,368
1902 ....Duty, 5 p.c.	15,584,164	603,582

BRITISH COLUMBIA :—

LEAD.
British Columbia.

Production.

The production of lead in British Columbia is shown in Table 7 below.

TABLE 7.

LEAD.

BRITISH COLUMBIA : PRODUCTION.

Calendar Year.	Pounds.	Price per Pound.	Value.
		cts.	
1887	204,800	4·50	$ 9,216
1888	674,500	4·42	29,813
1889	165,100	3·93	6,488
1890	Nil.	....	....
1891	"	....	....
1892	808,420	4·09	33,064
1893	2,131,092	3·73	79,490
1894	5,703,222	3·29	187,636
1895	16,461,794	3·23	531,716
1896	24,199,977	2·98	721,159
1897	38,841,135	3·58	1,390,513
1898	31,693,559	3·78	1,198,017
1899	21,862,436	4·47	977,250
1900	63,158,621	4·37	2,760,031
1901	51,582,906	4·334	2,235,603
1902	22,536,381	4·069	917,005

The various mining districts have contributed to the output for 1900, 1901 and 1902 as follows :—

TABLE 8.

LEAD.

BRITISH COLUMBIA : PRODUCTION BY DISTRICTS.

——	1900.	1901.	1902.
	Pounds.	Pounds.	Pounds.
East Kootenay—			
Fort Steele	38,494,077	29,129,128	3,017,756
Other districts	81,354	775,016	204,652
West Kootenay—			
Ainsworth	3,366,962	3,788,412	3,083,039
Nelson	1,485,899	2,470,350	1,680,948
Slocan	19,365,743	15,025,759	13,651,144
Trail Creek	1,045	....	....
Other districts	363,439	391,844	885,734
Yale	102	2,397	13,108
	63,158,621	51,582,906	22,536,381

MANGANESE.
Production.

MANGANESE.

Returns of the production of manganese for 1902 were incomplete and the figures of exports have been given as the closest approximation to the output. The exports were 172 tons valued at $4,062.

The production since 1886 is shown in Table 1 below :

TABLE 1.
MANGANESE.
ANNUAL PRODUCTION.

Calendar Year.	Tons.	Value.	Value per ton.
1886	1,789	$41,499	$23 20
1887	1,245	43,658	35 07
1888	1,801	47,944	26 62
1889	1,455	32,737	22 50
1890	1,328	32,550	24 51
1891	255	6,694	26 25
1892	115	10,250	89 13
1893	213	14,578	68 44
1894	74	4,180	56 49
1895	125	8,464	67 71
1896*	123½	3,975	32 19
1897*	15¼	1,166	76 46
1898	50	1,600	32 00
1899	1,581	20,004	12 65
1900	30	1,800	60 00
1901*	440	4,820	10 95
1902*	172	4,062	23 62

* Exports.

MANGANESE.

Exports.

TABLE 2.

MANGANESE.

EXPORTS OF MANGANESE ORE.

CALENDAR YEAR.	NOVA SCOTIA.		NEW BRUNSWICK.		TOTAL.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.
1873	....	....	1,031	$20,192	1,031	$20,192
1874	6	$ 12	776	16,961	782	16,973
1875	....	200	194	5,314	203	5,514
1876	21	723	391	7,316	412	8,039
1877	106	3,699	785	12,210	891	15,909
1878	106	4,889	520	5,971	626	10,860
1879	154	7,420	1,732	20,016	1,886	27,436
1880	79	3,090	2,100	31,707	2,179	34,797
1881	200	18,022	1,504	22,532	1,704	40,554
1882	123	11,520	771	14,227	894	25,747
1883	313	8,635	1,013	16,708	1,326	25,343
1884	134	1,054	469	9,035	603	20,089
1885	77	5,054	1,607	29,595	1,684	34,649
1886	(a) 441	30,854	1,377	27,484	(a)1,818	58,338
1887	578	14,240	837	20,562	1,415	34,802
1888	87	5,759	1,094	16,073	1,181	21,832
1889	59	3,024	1,377	26,326	1,436	29,350
1890	177	2,583	1,729	34,248	1,906	36,831
1891	22	563	233	6,131	255	6,694
1892	84	6,180	59	2,025	143	8,205
1893	123	12,409	10	112	133	12,521
1894	11	720	45	2,400	56	3,120
1895	108	6,348	$\frac{3}{10}$	3	$108\frac{3}{10}$	6,351
1896	$123\frac{1}{2}$	3,975	....	....	$123\frac{1}{2}$	3,975
1897	$15\frac{1}{4}$	1,166	....	....	$15\frac{1}{4}$	1,166
1898	11	325	....	....	11	325
1899	67	2,328	3	82	70	2,410
1900	....	....	....	....	34	1,720
1901	....	....	....	....	440	4,820
1902	....	....	....	....	172	4,062

(a) 250 tons from Cornwallis should more correctly be classed under the heading of mineral pigments.

Imports.

TABLE 3.

MANGANESE.

IMPORTS: OXIDE OF MANGANESE.

Fiscal Year.	Pounds.	Value.	Fiscal Year.	Pounds.	Value.
1884	3,989	$ 258	1894	101,863	$4,522
1885	36,778	1,794	1895	64,151	2,781
1886	44,967	1,753	1896	108,590	4,075
1887	59,655	2,933	1897	70,663	2,741
1888	65,014	3,022	1898	130,456	5,047
1889	52,241	2,182	1899	141,356	5,539
1890	67,452	3,192	1900	126,725	4,155
1891	92,087	3,743	1901	272,134	8,176
1892	76,097	3,530	1902 Duty free	476,331	5,360
1893	94,116	3,696			

MANGANESE. The manganese deposits of Canada were described in a previous annual report of the Mines Section. The present more extended article, bringing our information up to date, has been compiled by Mr. Theo. Denis from all the available published information.

Although Canada has not so far taken a very prominent place among the manganese producing countries of the world, the reason for this is not due to the lack of deposits of the ores of this metal. By far the greater proportion of the world's production, some 90 per cent of it, is used for the manufacture of ferro-manganese and spiegeleisen. These two alloys of iron and manganese differ from each other only in the proportion of manganese which they contain; up to 30 per cent of manganese the admixture is called spiegeleisen, whereas, when containing greater proportions it is called ferro-manganese, the standard of the latter containing 80 per cent of manganese. These alloys are manufactured to contain all degrees of proportions of the two metals, some spiegeleisen holding as little as two per cent of manganese, whereas high grade ferro-manganese contains as much as 90 per cent. They are used exclusively by steel manufacturers for the production of certain steels of great toughness used for stamp mill dies and shoes, crushing rolls, car-wheels, etc.

Uses of manganese.

The extension of manganese production depends greatly on the development of steel manufacture, and as Canada is now making great strides in that direction, its deposits will probably assume before long a much greater importance than heretofore.

Besides the manufacture of steel, manganese ore has several other very important uses, the main one of which is its use as an oxidizing agent in the manufacture of certain chemicals, such as bromine, chlorine manganates and permanganates; it is also one of the elements of the Leclanché cells; it is also used as a decolorizer of glass; as a coloring material in dyeing and in the manufacture of pottery and of paints, etc.

When the manganese ore is used as an oxidizing agent in the manufacture of chemicals, certain requirements of purity and composition are necessary which are not needed in the ore consumed for spiegeleisen and ferro-manganese, and it has therefore a value three to four times greater than that used for the latter purpose. Pyrolusite is the ore of manganese which has the greatest oxidizing power, and as the ore of some of the Canadian deposits contains a large proportion of this mineral, it is specially well adapted to that use. In Canada the ores represented comprise pyrolusite, manganite, psilomelane and wad or bog manganese ore. The principal deposits of the crystalline ores of manganese of the eastern provinces are referred by Dr. Gilpin to a

horizon low down in the Carboniferous marine limestones, in most cases underlying the lowest beds of gypsum, yet that these ores have a wider distribution is shown by the fact that wad or bog manganese is found in superficial deposits connected with every geological formation known in Nova Scotia and New Brunswick; moreover, occurrences of pyrolusite have been noticed in the quartzites of lower Cambrian age and in granites, also in quartzites and slates of presumably Silurian age, and in Triassic trap rocks. MANGANESE.

Origin of manganese deposits.

Dr. Penrose* ascribes the origin of manganese deposits to secondary action and contends that the source of the manganese ores found in the Palæozoic and later sedimentary rocks, is to be traced to the underlying archæan rocks and various igneous rocks of all ages. The fact that the largest manganese deposits in the United States and Canada are in the neighbourhood of such rocks is in itself suggestive; but when it is found that large areas of bog manganese ore occupy basins in the decayed surface of the pre-Palæozoic rocks, and that the river pebbles in areas of these rocks are frequently encrusted with a black coating of oxide of manganese, other facts are encountered which at once suggest a possible pre-Palæozoic source for manganese deposits. Moreover, when it is observed that volcanic breccias are sometimes cemented by manganese, that segregated masses of oxide of manganese are sometimes found in lava, and that the manganese nodules dredged up from the sea bottom are in intimate association with volcanic debris, the possible source of manganese in igneous rocks claims attention. When these two classes of rocks, pre-Palæozoic and igneous, especially the former are examined in their more minute details, and it is found that of the minerals composing them, those containing manganese, are among the most common, the probability of their being the source of manganese in the younger rocks becomes established. The different steps of the formation of manganese deposits begin as follows:

1. The derivation of the manganese from the decay of the Archæan and other pre-Palæozoic rocks and from the products of igneous action.

2. The solution and transportation of the manganese in the form of soluble organic and inorganic salts of the metal.

3. The precipitation of the manganese as oxide or carbonate.

4. The conversion of the carbonate into oxide.

5. The subsequent decay of the rocks which were deposited with the ore and an accompanying change in the nature of the ore and sometimes in its physical condition. That is to say, that the stages

* Penrose.—Geol. Surv. of Arkansas, 1890.

MANGANESE. in the history of the manganese deposits involve first, a decay of the rocks in which manganese is originally present as a constituent; secondly, a series of chemical reactions leading to a redeposition, and thirdly, a decay of the rocks of those newly formed deposits. As Dr. Penrose remarks very appropriately, the various stages in the formation of manganese deposits are similar in many respects to those known usually to have gone on in the formation of certain iron ores, but differ in minor details. Both metals have their origin in the same rocks; they go into solution in the same manner; but in the mode of redeposition, though they sometimes resemble each other, they often differ considerably in the chemical changes which go on in the subsequent alteration of the oxides. Hence manganese is often associated with iron ore deposits and sometimes is comparatively free from such accompaniments.

In the following description of the known deposits of manganese ore in Canada, the localities will be taken, as far as possible, in their geographical order from east to west, and not in the order of their relative economic importance.

Nova Scotia. NOVA SCOTIA.

This province possesses some of the most important deposits of manganese known in Canada, and as the iron and steel industries in that region are fast developing, these may, in the near future, become important sources of ore.

In Cape Breton, manganese ore is found in the western part of the county of that name. The most important belt of manganese-bearing ore crops out in the district of the head waters of the Salmon river and Loch Lomond. The rocks are of lower Carboniferous age and are met with in a valley between the felsites of the Mira and East Bay hills.

From personal observations and from notes furnished by Mr. Hugh Fletcher, of the Geological Survey of Canada, Mr. Edwin Gilpin describes the general conditions of the occurrence of the ore as follows* :—"The felsites of the Mira hills form a series of bays along which are exposed Carboniferous limestones, conglomerates, shales and grits as they were accumulated, subject to the varying conditions of the winds and currents of the period under consideration. At some points the limestones rest on the felsites; at other localities, grits and shales intervene; elsewhere, the basal conglomerates are covered directly by the millstone grit. The manganese ores were discovered

* Gilpin.—Manganese ores of Nova Scotia.—Trans., R.S.C., Vol. II.

MANGANESE. Nova Scotia.

two years ago in one of these recesses where the felsites were succeeded by shales and grits, and finally by limestones, the latter apparently extending from point to point of the ancient bay. The ores at the western mine are found in irregular bedded layers in a soft arenaceous reddish-coloured shale, which is in some places calcareous and coated with films of manganese oxide. The layers vary in thickness up to eighteen inches, and are frequently connected by cross stringers of ore. The shales when weathered present the ore in small nodules, and the disintegration of the former by water probably indicates the source of the beds of gravel manganese ore found lying on them. The ore at the eastern mine occurs as a bed immediately underlying a layer of black manganiferous limestone, with red and greenish shales and coarse grit. The thickness of the ore and limestone varies from two to eight inches, the average thickness of the two being about eight inches. The ore also occurs in this vicinity as lenticular pockets and irregular nests in conglomerate, &c., and sometimes forms the cementing material. The latter mode of occurrence is similar to that shown by the red hæmatites (sometimes highly manganiferous) found at various points in the Lower Carboniferous conglomerates of the island near their junction with older strata."

This deposit was first opened in 1880 by the Hon. E. T. Mosely, of Sydney, and has been worked at two places about three-quarters of a mile apart, near the head of Loch Lomond, eight miles south of the village of Big Pond on East bay. At the most easterly of these, the workings are on a vein about seven inches thick, dipping at an angle of 25° "in red fine sandstone overlying reddish and greenish grit with grains of quartz about the size of wheat, and red marly limestone, red and greenish shale, conglomerate and other rocks, blotched with calc-spar. It is in lenticular layers and also intimately mixed with the limestone, being probably of the same nature and origin as the hæmatite, and forming at times a covert for the pebbles of the conglomerate." *

At the western workings the ore is found in the bedding planes of a bright red argillaceous shale overlaid by calcareous argillaceous shale and limestone, and underlaid by conglomerate. The rocks have here a dip of 32°. Although these steep dips show the result of a general disturbance of the region, yet the rocks have not been as minutely shattered as might be expected. The ore is found both crystalline and massive, a great proportion being pyrolusite ; it is very free from iron and remarkably pure, and is well adapted to chemical manufacture. Besides the ore mined from the two workings above mentioned, a large quantity was obtained as drift nodules in the rock beds. These

* Fletcher, Hugh.—Geol. Survey Rep., 82-83-84.

MANGANESE. Nova Scotia.

nodules have been washed out of the original decayed rock, and on the outside are earthy, but on breaking, the interior shows the bright black surface of fresh ore.

On Boulardarie island, in the vicinity of Big harbour, a deposit of wad or bog manganese occurs. The deposit is stated to be several feet thick and extensive, but there is a great lack of uniformity in the composition of the ore in different parts of the bed.

There are other occurrences of manganese ores in Cape Breton county. In a limestone quarry at Salem road some pockets of manganese were encountered and mined in 1897. The rocks are of Lower Carboniferous age.

Some samples of wad received at the laboratory of the Geological Survey are said to have been obtained from a deposit situated at the head of Lewis bay.

Hants County.—On the south shore of Minas Basin there is a development of Lower Carboniferous limestone which from the Shubenacadie river extends westward for a distance of about forty miles, as far as the estuary of the Avon. This belt contains a limestone band some 300 feet thick in which are found the most important deposits of manganese of the region, the largest and best known of which are the Tenny Cape mines. It underlies the gypsiferous horizon, and Mr. Fletcher says of it that "next to the gypsum, the most interesting member of this formation is the red basal limestone, along which the manganese ores are found. It is of considerable thickness, concretionary, brecciated and associated in places with red conglomerate and grit." About fifteen miles south of Tenny Cape, near Windsor and at Douglas, the manganiferous limestone reappears. The occurrence of manganese, however, is not confined to the limestone, but it has also been noticed in the Devonian sandstone which is found below the Carboniferous marine limestone, and in places it occurs in large enough quantities to be worked. In this class of deposits which are not in the immediate vicinity of the limestone, the ore occurs in veins, joints or blotches, from one-quarter of an inch to five inches, in Devonian quartzites and shales. The important manganese veins of the district, however, are in the limestone above mentioned, lying at the base of the Carboniferous formation. Work on a comparatively large scale has been performed at Tenny Cape, Walton and Cheverie.

Tenny Cape Mines.—These are the most important workings of the region, and have been worked since 1861. The quantity of ore produced is not very gr at but has been described as the purest and

most beautifully crystallized pyrolusite found in America. It has of course been chiefly used in the manufacture of chemicals, glass decolorizing, etc. Of the deposit Mr. H. Fletcher writes as follows: "The rock, a twisted, reddish, shaly or brecciated dolomite is sometimes separated by two to four inches of hard red clay from the Devonian sandstone or quartzite which forms the foot-wall or floor of the mine. The ore occurs in veins, strings, nodules and masses. One of the latter is said to have yielded one thousand tons associated with calcite, selenite, barite, and limonite but in some places almost entirely free from foreign matter, It occupies the lines of jointing and bedding, breaks apart the fragments of the breccia and replaces the shale and limestone. The latter dips S. 20°E. at a variable angle, beneath a mass of gypsum; it has been worked for about 200 yards on the strike and the whole distance tested is probably less than 500 yards." The workings, as may be inferred from the wavy nature of the deposit, are scattered and irregular; they consist of open cuts. tunnels and shafts, the deepest of which a few years ago was 170 feet

MANGANESE. Nova Scotia.

The Parker Mine.—This is situated to the north of the Tenny Cape mine, about three-quarters of a mile from it. The deposit is in a much disturbed limestone, forming apparently an outlier of the Carboniferous basal beds among rocks of Devonian age. In 1881 some thirty tons of excellent pyrolusite were mined, but since then the work has been mostly of a prospecting and development nature.

The Churchill or Walton Mine.—This is on the west bank of Walton river immediately above the bridge, on the shore road some twelve miles north-east of Cheverie. The deposit worked here is also in an outlier of red and gray limestone filling a hollow in red Devonian quartzite and shale. The ore is mainly pyrolusite with some manganite and is associated with calcite crystals and barite. Some large masses of very high grade ore have been mined from this deposit.

In this vicinity, the main development of the manganiferous limestone is encountered a short distance south of the outlier on which is the Walton mine, and these two bear to each other the same relation as the Parker mine deposit does to the Tenny Cape mines. The limestone crosses the Walton river south of Walton, and on both sides of the river extending some distances east and west, it has been subjected to a great deal of prospecting and preliminary work. One of the more important properties is the Stephens mine.

The Stephens Mine.—Of this deposit Mr. Willimott of the Survey, as the results of observations made in 1883, writes as follows: "This mine is situated near the village of Walton, in Hants county, and

MANGANESE. Nova Scotia.

consists of an excavation of about thirty feet in depth, in a reddish shaly limestone, striking E. and W. with a southerly dip. Pockets and irregular veins of manganite and pyrolusite can be traced along the strike for about 400 yards.

Nothing beyond the preliminary prospecting work, scarcely sufficient to develop this promising mine, had been done at the time of my visit. Mr. Stephens informed me that about ten tons of fair grade ore had been taken out during the progress of their investigations. The limestone belt is perhaps continuous to Hibernia where a quantity of ore was found in reddish calcareous grit interstratified with concretionary limestone."

Sturgis Mine.—At this place which is about two miles west of Walton, manganese ore occurs in somewhat large quantities, as stringers, veins and films, or impregnations and stains in large masses of both the limestone and of the underlying flinty sandstone, in both of which shafts have been sunk and tunnels driven.

Tomlinson Mine.—This is situated west of the above mine and consists of openings made in the reddish and grey quartzite which underlies the limestone. These openings show masses of pyrolusite and hæmatite, sometimes mixed, sometimes separated.

Lantz Mine.—Several shallow pits have been opened in limestone, and from these workings some fine specimens of pyrolusite were obtained.

The Cheverie Mine.—This is situated near the village of Cheverie and the deposit here worked underlies the gypsum of the Cheverie quarries. The ore, a mixture of pyrolusite and manganite, occurs in a reddish and grey concretionary limestone, and is associated with white calcite in a network of small veins, from an eighth of an inch to three or four inches in thickness. Frequently the calcite associated with the manganese is in long crystals standing at right angles to the wall of the veins and forming a comb structure on both sides of the manganese.

According to observations made by Mr. H. Fletcher, at Cheverie, the ore is found near the top of the manganiferous band of limestone, at Walton it is found at the base of it near the contact with the underlying quartzite, and at Tenny Cape the best development of ore is met with at some thirty-seven feet from the bottom.

Minasville or Moose Brook Mines.—This mine is situated some four miles northeast of Tenny Cape. The occurrence of manganese ore here is not in the limestone, but in the underlying Devonian quartzites, where it is found in joints, veins and blotches, varying from a quarter

of an inch to five inches in thickness. A certain quantity of ore has been shipped from these workings. MANGANESE. Nova Scotia.

The same geological conditions are observed at Bear brook and at a deposit east of Noel river, where some preliminary work yielded small quantities of pyrolusite.

In Hants county other occurrences of crystalline manganese ores, more or less important have been noticed at Douglas, Rawdon, Goshen and other places. Bog manganese occurs near Goshen, south of Cheverie, at the head of Bass creek.

Colchester County, East Onslow.—At this place is the most important deposit of manganese now known in Colchester county. The ore occurs in the joints and bedding planes of old Devonian quartzite. In some places the ore which consists mainly of pyrolusite, is a foot thick; some manganite and psilomelane are also encountered. Operations were begun on this deposit in 1886 or 1887 and have since been carried on intermittently. The principal workings consist of a shaft fifty-five feet deep, and a large irregular cut.

Valley, Manganese Mines.—At Manganese mines near Valley, a quantity of black oxide of manganese is found in irregular veins cutting a reddish, slaty rock, which underlies the Carboniferous limestone.

Farham's Mill brook.—From the appearance of the occurrence of manganese at this place the deposit is a contact deposit between grey, rusty, concretionary, massive Carboniferous limestone and Devonian rocks. The ore occurs mostly in pockets in the limestone which also contains disseminated hæmatite, giving the rock a mottled weathering appearance.

Other occurrences of manganese ores have been noted on both shores of Minas basin in Colchester county. At Black Rock mine, near Clifton, at the mouth of the Shubenacadie river some work was done on a deposit in limestone. The ore which was of a ferruginous and magnesian nature was found in small quantities.

On the north shore of Minas basin at Lower Economy several barrels of fine crystalline pyrolusite were obtained in 1891. The occurrence is similar to those of East Onslow.

Besides the above occurrence, manganese is also found in large quantities associated with the important deposits of iron ores of Londonderry iron mines. The iron ore is found as veins of brown hæmatite accompanied by ochre, ankesite and sideroplesite. In places secondary

MANGANESE.
Nova Scotia.

changes have enriched the iron ore with manganese peroxide to the extent of fourteen per cent of its total constituents.

Other localities in Nova Scotia where occurrences of manganese ores have been observed, are as follows :—

In Cumberland county, Minudie, some small quantities of soft fine-grained pyrolusite were obtained from the Lower Carboniferous limestone. At Amherst (Cumberland) some manganese ore occurs in the same formation.

At Springhill (Cumberland) and Parrsboro', wad is met with in superficial deposits.

At New Ross, in Lunenburg county, a few shipments of ore are said to have been made from the college grant. The ore appears to be a mixture of psilomelane and manganite occurring in veins sometimes three feet in thickness. Wad is reported to occur at La Have and Chester, Lunenburg.

In Pictou county deposits of manganese ore are met with in connection with the iron ore deposits at Bridgeville and at Springhill, where boulders and concretions of psilomelane, manganite and wad are found.

In Antigonish county, near the head of the Ohio settlement, large pieces of pyrolusite were found in the drift on a hill, and in the same county occurrences of wad have been noticed near Afton; in Pomquet river; in Sutherland's brook and on a hill west of Piedmond station.

In King's county, near Wolfville, pyrolusite is found in small masses and stringers, in slates of Devonian age.

In Halifax county, at Musquodoboit and Ship Harbour, pyrolusite occurs as veinlets in granite, and at Jeddore, wad is found in the superficial deposits.

New Brunswick.

NEW BRUNSWICK.

The geological characters of the manganese deposits in New Brunswick resemble those of Nova Scotia. They are found in rocks of pre-Carboniferous age as well as in Lower Carboniferous measures, besides the superficial deposits of wad. The most important deposits, from an economic standpoint, are, however, those found in the Lower Carboniferous limestone.

Gloucester County.—In the vicinity of Tête à Gauche Falls, some eight miles from Bathurst, a deposit of pyrolusite occurs, in the red slates of the district which are probably of Cambrian age. The ore is found in numerous small veins, some of which are said to be as wide

as eight inches; and detached masses of it are often found in the superficial deposits in the neighbouring fields. This occurrence was the first to attract attention to the manganese ores of the province; it was worked a number of years ago, and a certain quantity of ore is said to have been shipped from this place. As a result of personal examination, Dr. Bailey is of opinion that the district is worthy of closer examination than it has yet received. Unfortunately, the conditions are not very favourable to easy prospecting, as the district is flat and deeply covered with clayey soil.* MANGANESE. New Brunswick.

King's County.—In this county are the deposits of Markhamville, which are the most important ones of the province. The ore deposits were examined by Dr. Penrose in 1890, and as a result of his visit he describes them as follows:

† "The Markhamville mine is situated at the village of Markhamville near the head of Hammond river in Kings county about forty miles north-east of St. John, about fifteen miles north of the shore of the Bay of Fundy, and about eight miles south of Sussex on the Intercolonial railway. The existence of manganese was notod at the head waters of the Hammond river many years ago by Mr. Geo. F. Matthew, of the Geological Survey of Canada, but the property was first opened about 1864 under the management of Major A. Markham. Major Markham was the first to attempt to develop in a systematic manner the manganese deposits of this province, and it is due to his energy and perseverance that the ores have been introduced into the market

"The ore occurs either as crystalline pyrolusite and manganite, or in a compact, massive, nodular or bedded form, sometimes containing psilomelane.

"The ore-bearing limestone is generally of a gray colour, but at times is pink or buff, and is associated with shaly strata. It contains veins of crystalline calcite in which masses of pyrolusite are frequently found, but the principal ore deposits are lenticular bodies interstratified with the limestone. These ores occur as irregular pockets or as flat layers more or less continuous for considerable distances, and becoming thin and thick at intervals. In some places such deposits widen out into pockets from which several hundred tons of ore have been taken and in one opening 3,000 tons are said to have been mined. Though in places the pockets do not always adhere strictly to the bedding of the rock, yet in a general way they follow it. Sometimes

* Annual Report Geol. Surv. of Can., Vol. X. (N.S.), 1897. Part M.

† The Manganese deposits of U. S. and Canada, by Dr. Penrose. Geol. Survey of Arkansas, vol. I., 1890.

MANGANESE.

New Brunswick.

veins and pockets cut directly across the bedding, but these are generally smaller than the others and are probably due to a secondary chemical action by which they have been derived from the bedded ores.

"The surface of the limestone has often been decomposed, and a red residual clay, frequently mixed with surface gravel, has collected in considerable quantities. The ore that was originally in the part of the limestone which has decayed, is now found buried in the clay; and therefore deposits of ore-bearing clay or gravel, overlying the partly decomposed surface of the limestone, are of frequent occurrence. Such deposits are rarely more than from eight to twenty feet in thickness, but the ore in them is cheaply worked and they have supplied a large part of the output of the Markhamville mine. Frequently the decomposition of the limestone has spread downward more rapidly along the outcrop of a body of ore than elsewhere, causing somewhat abrupt hollows filled with residual clay and manganese ore and containing in the bottom the outcrop of the ore in situ in the rock.

"Not only has decomposition taken place on the surface but it has also gone on to a considerable extent underground frequently causing subterranean cavities and passages. When these have intersected bodies of manganese the floors are covered with loose fragments of ore, brought there in the same way as that in the residual clay on the surface. Kidney-shaped masses of glossy, black limonite are frequently found with the cave deposits, and these also have doubtless come from the limestone.

"Though a large amount of manganese has been taken from the surface clay beds and the caves, yet the deposits of ore in the limestone have also been extensively worked, and in many places the rock is honeycombed with a network of shafts and drifts, following the erratic courses of the ore bodies in all their intricacies.

"The thickness of the limestone varies considerably: in one of the pits a depth of twelve feet was found, and a diamond drill boring in another part of the property showed a thickness of fifty-five feet. Probably a greater thickness will be found elsewhere. The bed is much disturbed and is folded into small anticlines and synclines, but at Markhamville it has a general dip to the northwest and a strike of northeast and southwest. In many places it contains fossils, and sometimes the carbonate of lime of these has been partly replaced by manganese, which has subsequently been oxidized and now exists as a black, more or less calcareous mass.

"The Hammond river rises near Markhamville and flows south-west, parallel to the coast of the Bay of Fundy, until it finally turns south

and empties into the bay about eight miles south east of St. John. In MANGANESE. the region of Markhamville, and for some miles down the river, the New Lower Carboniferous limestone occupies the centre of the valley; but Brunswick. it is only locally that manganese occurs in it, and only at the Markhamville mine that it has yet been found in large quantities.

"The limestone area is bordered on the south by a range of hills which forms the southern barrier of the Hammond river valley. According to information kindly furnished by Mr. G. F. Matthew, of the Geological Survey of Canada, these hills are composed largely of the underlying pre-Cambrian rocks, and the Carboniferous rocks dip away from them. To the north of the river the limestone is cut off in many places by an abrupt escarpment of Carboniferous conglomerate, which according to the same authority, probably belongs above the manganese-bearing limestone.

"The ore from this mine is mostly used for chemical purposes. It is prepared for market by crushing, washing and sizing with screens. Certain quantities of the lower grades, however, are shipped without previous preparation, under the name of "furnace ore" and are used in the manufacture of spiegeleisen and ferro-manganese."

The importance of the Markhamville mines may be realized by the fact that between 1868 and 1894, the total exports of manganese ore from New Brunswick amounted to over 23,000 tons representing a value of nearly $410,000, almost the whole of which, was derived from the Markhamville deposits. (Dr. Bailey, Mineral Resources of New Brunswick.)

King's County, The Glebe mine.—The deposit of the Glebe Mine is situated some three miles N.N.E. of the Markamville vein, and seven miles from Sussex station on the Intercolonial Railway.

Dr. Penrose in his bulletin on the manganese ores of America describes this occurrence as follows:—"The ore is found in a limestone resembling that at Markhamville, though it is much less disturbed than at that place and dips gently to the west. The manganese ore occurs in the limestone in nodules and thin layers, frequently associated with calcite and following the general direction of the stratification. Several shafts and tunnels have been made, the deepest shaft being 85 feet."

King's County, Jordan Mountain.—This deposit is situated on the south-eastern side of Jordan mountain, about seven miles from Sussex station on the Intercolonial Railway. According to Dr. Bailey, the

MANGANESE.

New Brunswick.

geological relations here are similar to those of Markhamville; the ore is found in strata of Lower Carboniferous age near their contact with older metamorphic rocks. But instead of occurring as in the last-named locality, in limestone, it is found in connection with shales and shaly conglomerate, the brecciated character of which is in contrast with the rocks at Markhamville. Work was begun on this deposit in 1882 and some good ore is said to have been extracted from an open cut. The ore is a mixture of pyrolusite and manganite occurring in lenticular interbedded masses. There are also small veins and stringers of manganese oxide penetrating the surrounding rocks.

King's County, Hillsdale.—Some fine surface indications of manganese ore are said to have been observed at Hillsdale about five miles south-east from Elgin corner. No particulars of this deposit are available.

St. John County, Quaco Head mine.—This is situated on the north shore of the Bay of Fundy on a promontory which forms the southern boundary of Quaco Harbour. The mine is about one mile south of the village of St. Martins. The following description of the deposit is taken from the bulletin by Dr. Penrose who examined it in 1890 when it was being worked by the Brunswick Manganese Company. "The manganese is sometimes crystalline representing pyrolusite and possibly also manganite, while at other times it is hard and massive, possibly representing psilomelane, and still again it is in porous honeycombed form. These ores are found in Lower Carboniferous shales and limestones, associated with a large conglomerate bed.

"The rocks are greatly disturbed and have been much shattered and broken by igneous intrusions. They now stand at steep angles sometimes almost vertically, exposing in different parts of the headland areas of limestone, shale, and coarse conglomerate. Masses of igneous material protrude into these beds at different points and on either side of the headland are beds of Triassic sandstone and fine conglomerate lying unconformably on the upturned edges of the older rocks.

"The manganese occurs as nodules and irregular discontinuous veins, in both the shale and the limestone, though the larger quantities are in the former. The nodules vary from a fraction of an inch to several inches in diameter, and the thickness of the veins is equally variable. The disturbed character of the rocks renders it somewhat difficult to determine the thickness of the main ore-bearing bed but it is probably not over thirty feet though smaller quanties of manganese are found in the rocks on either side. The ore is scattered through this thickness in very variable quantities. . . . . . .

"The igneous rock is a hard light gray, close-grained material of a texture somewhat like trap. The limestone is like that of Markhamville, though it is much reddened at the contact with the igneous rock. The conglomerate bed is composed of coarse pebbles of metamorphic rocks. It dips steeply to the south and forms a bold bluff on which the lighthouse of Quaco Head is situated. The sandstones and conglomerates at each end of the section are of a brick red colour and vary from coarse sandstone to a fine conglomerate, with pebbles from a quarter of an inch to one inch in diameter, both sand and pebbles being composed of white quartz stained by a ferruginous cement. Sometimes these beds contain small irregular seams or nodules of manganese ore, which, however, are in very limited quantity, and have doubtless been derived during the deposition of the beds, from the erosion of the Lower Carboniferous rocks.

MANGANESE. New Brunswick

"The ore-bearing rocks can be traced back on the promontory at intervals for almost a mile, to a place where an opening has been made on the farm of Mr. Molaskey. On the north side of the head, small scattered nodules of manganese ore are found in the gravel drift that lines that part of Quaco Harbour, and extends inland over the Lower Carboniferous rocks. They have doubtless been derived from the latter rocks during deposition of the gravel, in the same way that the red sandstone just mentioned obtained its manganese contents at an earlier date."

Subsequent to Dr. Penrose's visit the Brunswick Manganese Company erected a well-equipped mill, consisting mainly of a crusher, rolls, screens, two jigs, etc. The mine is exceptionally well situated for shipping by water. Operations have, however, been discontinued for several years.

Albert County, Shepody mines.—Shepody mountain is one of the highest eminences in southern New Brunswick. The lower part of this mountain is composed of chloritic hydro-mica schists, and the upper part consist of Lower Carboniferous strata; at the contact between these two sets of rocks are found the manganese occurrences.

Dr. Ells in his report for 1885* writes as follows:—"Shepody mountain, 1,050 feet high, is a rugged peak which forms a prominent landmark for many miles in all directions, and was one of the signal stations for the Admiralty survey of the Bay of Fundy. It is composed largely of red conglomerates, which are well exposed on the east flank in Robertson's brook and its branches. A deposit of reddish

* Geol. Surv., Can., Report of Progress, 1885.

MANGANESE. New Brunswick.

impure limestone has been opened up at this place for a marble quarry, but the rock was found to be too much shattered to be of great value. The limestone contains a small quantity of manganese. The rocks of the mountain rest upon a small outlier of the talco-chloritic schists which show on the road to the north, leading to Curryville, and are flanked on the east by the gray sandstones of the millstone grit. On the north-west side a large deposit of manganese was worked for some years, a tunnel being driven into the mountain along the contact with the underlying schists for nearly 1,000 feet. The ore, which consisted of pyrolusite and psilomelane occurred at the base of the conglomerate in irregular pockets."

The Shepody mountain mines were first opened in 1860, and it is said that 500 tons of ore was extracted. This were a compact black oxide, less crystallized than the ores of Markhamville, but of high grade. It was found both in veins and in interbedded masses.

Albert County, Elgin.—Gowland Mountain.—On the north-east side of the mountain some exploratory work revealed occurrences of pyrolusite and psilomelane in a very broken and decomposed granite of pre-Cambrian age.

In the same county, on the east side of Salisbury bay, a small deposit of manganese occurs near a contact of Lower Carboniferous and Triassic sandstones. This deposit was worked many years ago but shortly abandoned.

Albert County, Dawson Settlement.—At this place occurs a very important deposit of wad or bog manganese. Dr. Bailey, who visited the deposit in 1899, gives the following description, which is the latest and fullest available :—

"This very remarkable deposit is located about five miles and a half from the town of Hillsborough, on the slope of a hill inclining north-easterly at a low angle towards a small brook, flowing thence to the Petitcodiac river, and whose opposite slope is occupied by the settlement above named. The upper part of the first ridge is wooded, but between the edge of the latter and the brook the ground is cleared and upon removal of a thin coating of vegetable matter, usually not more than two inches in depth, is found to be everywhere covered with a very fine black powdery deposit consisting essentially of manganese oxide.

"The property, as leased, embraces an area of about 150 acres, and upon about eighteen or twenty acres, or as far as searched for, the ore has been found, the deposit varying in depth from a few inches to

thirty feet. In a survey recently made by a Crown land surveyor, seventy-three borings were made, in squares of 100 feet, over a space of seventeen acres, showing an average depth of six feet seven and three-quarter inches, equal to 1,900 pounds to the cubic yard. There is accordingly already in sight and available for use :—

MANGANESE. New Brunswick.

	Tons.
In situ on hillside, 17 acres	173,176
In drying-house and sheds...........................	400
Total......	173,576

According to the statements of the manager of the property Mr. R. P. Hoyt, to whom I am indebted for assistance and valuable information, the iron rods used in the above borings, in many of the deepest places, failed to go down over twenty-five or thirty feet, and then struck what was apparently hard manganese ore, so that the above results indicate the minimum quantity. These ores are, in comparison with those of Markhamville, low grade ores and would be of little or no value for the uses to which the latter are chiefly put, nor in their natural condition would they have commercial value of any kind. It is, however, proposed to subject them to a bricquetting process whereby the pulverulent and absorbent mass shall be rendered solid, non-absorbent, and capable of easy handling, in which condition it may be advantageously used in the manufacture of spiegeleisen and ferro-manganese. For this purpose an extensive plant embracing drying furnaces compressors, bricquetting machines, etc., has been erected close by the manganese deposits, and also near to the track of a branch railway one mile and a half in length, built by the company, and connecting with the Harvey and Salisbury Railway at a point eleven miles from Salisbury, whence, over the Intercolonial Railway the product may be readily shipped to all Canadian and United States points. The shipping point by sea is five miles and a half by rail from the mine to Hillsborough, with direct landing at wharf for vessels of 800 to 1,000 tons capacity." This company, "The Mineral Products Company of New York," sent the bricquettes to Bridgeville, Nova Scotia, where the smelting plant of "The Picture Charcoal Iron Company" had been secured for the manufacture of ferro-manganese. For some unknown reason, after a period of apparently successful operations this company have discontinued work.

Besides this deposit of wad, other deposits have been noticed at different places, among which are Queensbury, York county; north branch of S. W. Miramichi; in gravelly bank near government house

MANGANESE. New Brunswick.

at Fredericton; near Harvey, Albert county; Bull Moose Hill, Kings county; Moore's Mills, Charlotte county and other places.

As to the probable origin and mode of formation of the deposits of wad or bog manganese, Dr. Chalmers* assigns it to the action of springs.

In the case of the Dawson Settlement deposit, the bed of wad lies in a valley at the northern base of a hill, and springs are trickling down the hillside; doubtless the process of formation of bog manganese is still going on. Dr. Bailey on the same subject writes as follows:

"An interesting question in connection with these deposits is that of their probable origin. Upon this point the locality throws very little light, there being absolutely no exposures of rocks anywhere in the vicinity or any visible source from which the manganese may have come. The nearest rocks are indeed those of the millstone grit, though these are doubtless underlain, as at Hillsborough and about the Albert mines by Lower Carboniferous rocks, including limestones. None of these however, are markedly manganiferous. It is also a little singular that the deposit should have such a decided slope instead of being, as usual with bog ores, nearly horizontal. Finally, the abruptness with which the deposits end along the line of the brook referred to above, towards which it inclines while no such material is to be found on the opposite slope, is also remarkable, and seems to suggest that the ores are the result of deposition from springs originating on the one slope but wanting on the other, while the brook has carried off the excess of the solvent water. In support of this view it may be observed that the hillside on which the ore beds rest, is remarkable for the number of springs which issue from its surface, in the waters of which both iron and manganese may be readily detected."

Quebec.

QUEBEC.

In this province the only occurrences of crystalline manganese ore are those of the Magdalen islands in the Gulf of St. Lawrence. From an examination of these islands Mr. Jas. Richardson in the report of the Geological Survey for 1879-80 writes as follows: "Immediately under Demoiselle hill, on Amherst island, numerous blocks charged with peroxide of manganese or pyrolusite, occur among the debris of the fallen cliffs. They are in pieces varying from one pound to ten or fifteen pounds in weight. There can be little doubt that they are derived from a deposit more or less regular in the hill side, but which

* Annual Report Geol. Surv. Can., Vol. VII, (N.S.), 1894, Part M.

is now completely concealed by the fallen debris. At a place bearing nearly due west from Cap aux Meules, at the distance of about a mile, and close to the English Mission church, similar pieces to those above described are very frequently picked up." These deposits have lately attracted some attention, and in 1903 were purchased by a syndicate which intend working them. MANGANESE. Quebec.

Wad or bog manganese has been observed at a great number of points in this province but the quality is poor as a rule, and of small commercial value. Of these deposits one of the most considerable is in the township of Stanstead, lot 9, range X; This deposit is stated to cover an area of about twenty acres with a maximum thickness of about twelve inches. Some of this ore after undergoing a washing to free it from the sand, gave 37 per cent of peroxide.

Another deposit of several hundred square yards in extent with a maximum thickness of six inches was observed in the township of Bolton, lot 20, range XII.

Mr. A. P. Low, mentions the occurrence of wad on the St. Louis road some four miles and a half from Quebec. The deposit here is about sixty yards by five with a maximum observed thickness of twelve inches.

The following other occurrences were compiled from the reports of the Geological Survey. The majority are of limited extent.

On the road from Lambton to St. Francis, Beauce county, near the eastern boundary of the township of Tring; on the west side of the Chaudiere river, opposite the mouth of the Famin river; in the seignory of the Mesy; in the seignory of Ste. Anne de la Pocatiere in rear of the church; in Cleveland township, county of Richmond, on lot 16, range XIII; in St. Sylvester lot 9, range St. Charles; in Gaspe seignory, half a mile west of St. Apollinaire church.

UNGAVA TERRITORY.

Ungava Territory.

In his report on the east coast of Hudson bay, Dr. Bell mentions the occurrence of very important deposits of spathic iron ore in the Nastapoca chain of islands. These ores are in places very rich in carbonate of manganese; an average specimen from Flint island yielded 25·44 per cent metallic iron and over 24 per cent of carbonate of manganese. These deposits are very accessible and may some day be worked profitably. The high contents of manganese in these ores would render them valuable in the manufacture of spiegeleisen.

ONTARIO.

Ontario.

There are very few occurrences of ores of manganese in this province, and none of these has been worked. One of the first discoveries

MANGANESE. Ontario.

is that of Bachewanung bay on Lake Superior, which is described as follows in the "Geology of Canada 1863."

"At Bachewanung bay, near the southwest end of the Upper Canada Mining Company's location, and not far from the shore is a large vein of manganese ore, running north and south, and from fifty to sixty feet wide. It is described as presenting the aspect of a succession of small knobs, in which, mixed with a reddish trappean rock, are numerous strings of the ore, associated with quartz and calc-spar, and occasionally with octahedral crystals of fluor. The ore, which is massive with small geodes of crystals, is described by Prof. Hadley as manganite or hydrous sesquioxide of manganese, which for manufacturing purposes is inferior to the peroxide. A specimen was found by assay to be equal to sixty per cent of peroxide of manganese."

In the Rainy lake district manganese has been discovered associated with the iron ore deposits to the north of Gunflint lake; an occurrence is described as follows by Mr. Conmee in the second report of the Ontario Bureau of Mines; "This range (iron ore) is near Sand lake, four miles from the Port Arthur, Duluth, and Western railway. The deposit has been found to be a large one. A pit has been sunk about 15 feet, and as far as the pit has shown up the vein, it seems to be very much decomposed. The ore assayed 65½ per cent. of iron and carried also a good percentage of manganese. The manganese appears to be dispersed among the iron, but it also occurs in pockets; they have taken out small quantities of manganese almost pure."

Wad or bog manganese occurs at several places in Ontario but has not attracted any attention, so that very little is known about them. An extensive deposit is said to occur in Hastings county, Madoc tp., lot 4, range V.

North-west Territories.

NORTH-WEST TERRITORIES.

In Assiniboia a deposit of manganese ore is reported to occur on the north bank of the north fork of Willow creek. Tp. 5, R. 1, west of 4th Mer.

Mr. Pearce gives the following description of the deposit: "The manganese is found in pockets in a honeycombed formation four or five feet thick, composed of clay and sand with no sulphur or lime. Taking the deposit as a whole, manganese is estimated to run 5 per cent."

British Columbia.

BRITISH COLUMBIA.

The only record available of discovery of ores of manganese in British Columbia, is that of important occurrences of bog manganese in Nicola

MANGANE

Ontario.

North-west
Territories

British
Columbia.

valley, but only a comparatively small part of the province has been thoroughly prospected, and it is very probable that rich deposits exist which have not yet been found. MANGANESE. British Columbia.

REFERENCES.

References.

BAILEY, L. W.—The Mineral Resources of New Brunswick, Report Geol. Survey Vol. X, 1897, Part M.

BELL, Dr. R.—Report on an Exploration of the East Coast of Hudson Bay. Report of Progress, Geol. Survey of Canada, 1877-78.

BRUMMEL, H. P. H.—Report Geological Survey of Canada, 1890, Part S. Vol. V.

DAWSON, Sir J. W.—Acadian Geology.

ELLS, Dr. R. W. –The Mineral Resources of the Province of Quebec. Report Geol Survey of Canada, Vol. IV, Part K.

FLETCHER, H.—Report on the Geology of Pictou and Colchester counties. Geol Survey of Canada, Vol. V, Part P.

FLETCHER, H.—Summaries of operations of Geol. Survey for years 1893 and 1901-02.

GILPIN, ED.—Mines and Minerals of Nova Scotia, 1880.

GILPIN, ED.—Notes on Manganese ores of Nova Scotia, Trans. Roy. Soc. Canada, Vol. LL.

GILPIN, ED.—The Minerals of Nova Scotia, 1900.

HOW, Prof.—Trans. Nova Scotia Inst. of Sc. Vol. I.

HOW, Prof.—How's Mineralogy of Nova Scotia.

JENNISON, W. F.—Manganese deposits of Nova Scotia. Trans. Can. Mining Inst., 1898.

MINERAL STATISTICS AND MINES.—Geological Survey of Canada. Annual Report, Mines Section, 1890-1, 1897-98.

PENROSE, Dr.—Manganese Deposits of America, Geol. Survey of Arkansas, Vol. I 1890.

WILLIMOTT, C. W.—Notes on Mines and Minerals. Geol. Surv of Canada, 1882-83-84, Part L.

MICA.

MICA.

The production of mica in 1902 in the provinces of Ontario and Quebec, according to the statistics published by the mining bureaus of these provinces was as follows : Production.

Quebec....................	132,822 lbs.	$ 34,304
Ontario....................	1,986,000 "	101,600
	2,118,822 "	$135,904

The above figures make the total production of mica in Canada of a value of $135,904. As the statistics of production published for 1901 and previous years were compiled on a different basis, being esti-

MICA.

Production.

mated from export returns and home consumption, it is inadvisable to draw comparisons between the above figures and those of previous years. The export returns have not been used as a basis for estimating the production in 1902, for the reason that it is believed they include for that year, large quantities of material manufactured from mica, such as mica boiler covering, etc.

TABLE 1.

MICA.

ANNUAL PRODUCTION.

Calendar Year.	Value.	Calendar Year.	Value.
1886	$ 29,008	1895	$65,000
1887	29,816	1896	60,000
1888	30,207	1897	76,000
1889	28,718	1898	118,375
1890	68,074	1899	163,000
1891	71,510	1900	166,000
1892	104,745	1901	160,000
1893	75,719	1902	185,904
1894	45,581		

Exports.

TABLE 2.

MICA.

EXPORTS.

Calendar Year.	Value.	Calendar Year.	Value.
1887	$ 3,480	1895	$ 48,525
1888	23,563	1896	47,756
1889	30,597	1897	69,101
1890	22,468	1898	110,507
1891	37,590	1899	153,002
1892	86,562	1900	146,750
1893	70,081	1901	152,553
1894	38,971	1902	(a) 391,812

(a) Probably includes some material manufactured from mica.

The monthly exports of mica to Great Britain and other countries and the United States in 1902 are shown below in Table 3, the statistics being compiled from the unrevised monthly statements of imports and exports of the Customs Department :

MICA.

Expor s.

TABLE 3.

MICA.

EXPORTS TO GREAT BRITAIN AND OTHER COUNTRIES AND TO THE UNITED STATES.

Months.	To Great Britain and other countries.		To the United States.		Total Exports.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
January....	2,925	$ 1,092	196,787	$ 42,909	199,712	$ 44,001
February	1,329	464	146,908	22,938	148,237	23,402
March.	2,400	865	84,572	15,768	86,972	16,633
April........	6,207	1,491	56,454	12,106	62,661	13,597
May.........	9,235	4,967	129,108	26,296	138,343	31,263
June	7,890	4,249	92,885	21,889	100,775	26,133
July.........	5,000	660	22,711	5,003	27,711	5,663
August	7,780	3,818	118,547	25,060	126,327	28,878
September....	3,000	1,800	133,645	26,308	136,645	28,108
October......	53,240	7,416	23,850	5,949	77,090	13,365
November....	2,810	725	73,101	34,231	75,911	34,956
December....	418,956	111,721	51,562	14,087	470,518	125,808
	520,772	139,268	1,130,130	252,544	1,650,902	391,812

British Columbia.—In the Summary Report of the Director of the Geological Survey for 1898, Mr. McEvoy mentions the occurrence of mica in the vicinity of Tete Jaune Cache, B.C., and describes some of the workings. Development in the district, however, has been hindered by the lack of proper trails, and the expense of transport. With regard to the work accomplished in 1902 the gold commissioner of the Golden Mining Division, B.C., reports as follows :—

"*Big Bend Mica Claim.*—A force of about twenty men were employed a portion of the summer in opening up the various claims but in order to get in supplies about 20 miles of new trail had to be built from the end of Timbasket Lake, on the east side of the Columbia river; consequently there was not as much work done on the claims as was anticipated, but the showing is said to be very encouraging.

"On the Bennison Group work has again been resumed and a force of six men were employed until late in the fall. It is the intention of the owners to recommence operations as soon as supplies can be got in." (Report of the Minister of Mines B. C., 1902, p. 133.)

Mineral Pigments.

MINERAL PIGMENTS.

Under this heading is included the production of ochres and baryta.

Ochres.—The output of ochres has been as usual derived chiefly from the deposits near Three Rivers, Champlain county, Quebec. The total production in 1902, according to returns received from producers was 4,955 tons valued at $30,495. The firms engaged in this production are: The Canada Paint Co., Montreal; The Champlain Oxide Co., Three Rivers; Thos. H. Argall, Three Rivers, Que., and the Ontario Mineral Paint Works, Kilbride, Ontario.

Statistics of production, imports and exports are given in tables 1, 2 and 3.

Production.

TABLE 1.

MINERAL PIGMENTS.

ANNUAL PRODUCTION OF OCHRES.

Calendar Year.	Tons.	Value.
1886	350	$ 2,350
1887	485	3,733
1888	397	7,900
1889	794	15,280
1890	275	5,125
1891	900	17,750
1892	390	5,800
1893	1,070	17,710
1894	611	8,690
1895	1,339	14,600
1896	2,362	16,045
1897	3,905	23,560
1898	2,226	17,450
1899	3,919	20,000
1900	1,966	15,398
1901	2,233	16,735
1902	4,955	30,495

TABLE 2.

MINERAL PIGMENTS.

IMPORTS OF OCHRES.

MINERAL PIGMENTS.

Imports.

Fiscal Year.		Pounds.	Value.
1880		571,454	$ 6,544
1881		677,115	8,972
1882		731,526	8,202
1883		898,376	10,375
1884		533,416	6,398
1885		1,119,177	12,782
1886		1,100,243	12,267
1887		1,460,128	17,067
1888		1,725,460	17,664
1889		1,342,783	12,994
1890		1,394,811	14,066
1891		1,528,696	20,550
1892		1,708,645	22,908
1893		1,968,645	23,134
1894		1,358,326	18,951
1895		793,258	12,048
1896		1,159,494	16,954
1897		1,504,044	18,504
1898		2,126,592	26,307
1899		2,444,698	31,092
1900		2,474,537	32,017
1901		2,092,067	27,267
	Duty.		
1902 { Ochres and ochrey earths and raw siennas	20 p. c.	978,095	$ 8,982
1902 { Oxides, dry fillers, fire-proofs umbers and burnt siennas N.E.S.	25 "	1,552,648	24,927
Total, 1902	....	2,530,743	$33,909

TABLE 3.

MINERAL PIGMENTS.

EXPORTS OF MINERAL PIGMENTS, IRON OXIDES &C.

Exports.

Calendar Year.	Tons.	Value.
1897	512	$7,706
1898	283	4,227
1899	308	5,408
1900	651	7,154
1901	401	8,233
1902	352	6,182

Baryta.—The production of baryta in 1902 was 1,096 tons valued at $3,957. This production was obtained from Cape Rouge, Inverness county, Cape Breton, and Hull township, Wright county, Quebec. Baryta.

MINERAL PIGMENTS.

Baryta.

The output is used almost entirely in the manufacture of paint.

Statistics of production and imports are given below in Tables 4, 5, 6.

Production.

TABLE 4.

MINERAL PIGMENTS.

ANNUAL PRODUCTION OF BARYTA.

Calendar Year.	Tons.	Value.
1885	300	$ 1,500
1886	3,864	19,270
1887	400	2,400
1888	1,100	3,850
1889	.....	.....
1890	1,842	7,543
1891	.....	.....
1892	315	1,260
1893	.....	.....
1894	1,081	2,830
1895	.....	.....
1896	145	715
1897	571	3,060
1898	1,125	5,533
1899	720	4,402
1900	1,337	7,605
1901	653	3,842
1902	1,096	3,957

Imports.

TABLE 5.

MINERAL PIGMENTS.

IMPORTS OF BARYTA.

Fisca Year.	Cwt.	Value.
1880	2,230	$ 1,525
1881	3,740	1,011
1882	497	303
1883	.....	185
1884	.....	229
1885	7	14
1886	.....	62
1887	379	676
1888	236	214
1889	1,332	987
1890	1,322	978

TABLE 6.

MINERAL PIGMENTS.

MISCELLANEOUS IMPORTS, FISCAL YEAR, 1902.

MINERAL PIGMENTS.

Imports.

—	Duty.	Quantity.	Value.
			$
Paint, ground or mixed in, or with either japan, varnish, lacquers, liquid dryers, collodion, oil finish or oil varnish...... Lbs.	25 p. c.	67,443	5,224
Paints and colours, rough stuff and fillers, anti-corrosive and anti-fouling paints commonly used for ship hulls, N.E.S. .... "	25 "	393,445	18,638
Paris green, dry .... "	10 "	655,085	80,818
Paints and colours ground in spirits, and all spirit varnishes and lacquers .... Galls.	$1.12½ par gallon..	708	2,148
Putty .... Lbs.	20 p. c.	155,338	2,615
Total	....	....	109,443

MINERAL WATER.

MINERAL WATERS.

Mineral springs are known to occur at many places throughout Canada, and at a number of them the water is being utilized, either bottled for sale throughout the country, or used for drinking or bathing purposes at the places where it is found. At several points hotels have been erected, at which the guests have the privilege of using the mineral water. In view of this, it is difficult to obtain statistics giving any intelligent idea of the extent or value of the industry. These facts should be kept prominently in mind when using the figures of production given in Table 1 below, as these are more or less approximations.

TABLE 1.

MINERAL WATERS.

ANNUAL PRODUCTION.

Production

Calendar Year.	Gallons.	Value.	Calendar Year.	Gallons.	Value.
1888..........	124,850	$ 11,456	1896..........	706,372	$111,736
1889..........	424,600	37,360	1897..........	749,691	141,477
1890..........	561,165	66,031	1898..........	555,000	100,000
1891..........	427,485	54,268	1899..........	....	100,000
1892..........	640,380	75,348	1900..........	....	75,000
1893..........	725,096	108,347	1901..........	....	100,000
1894..........	767,460	110,040	1902..........	....	100,000
1895..........	739,382	126,048			

MINERAL WATERS.

Imports.

TABLE 2.

MINERAL WATERS.

IMPORTS.

Fiscal Year.	Value.
1880	$41,797
1881	55,763
1882	57,958
1883	49,546
1884	48,613
1885	55,864
1886	47,006
1887	52,989
1888	54,891
1889	66,331
1890	71,521
1891	$15,721
1892	17,913
1893	27,909
1894	28,130
1895	27,879
1896	32,674
1897	22,142
1898	33,314
1899	38,046
1900	30,343
1901	40,802
1902 { Mineral waters, natural, not in bottle ... Duty free..	$ 492
1902 { Mineral and aerated waters ... " 20 p.c.	91,379
Total	$91,871

NATURAL GAS.

NATURAL GAS.

The total value of the natural gas sold in Canada in 1902 was $195,-992. This output is practically all derived from the wells in southern Ontario, although at Medicine Hat, Alberta, a small quantity is used for the burning of lime, etc. The large falling off in the amount of gas sold is doubtless due in a large measure to the action of the Ontario Government in ordering the suspension of the export of natural gas across the St. Clair river to Detroit. The falling off in supply of the gas had become quite marked, and the local Canadian consumers petitioned the government to put a stop to the export, which request, after an investigation was acceded to.

This restriction, however, does not apply to the Welland field, from which gas is still being exported to Buffalo.

NATURAL GAS.

Production.

TABLE 1.

NATURAL GAS.

ANNUAL PRODUCTION.

Calendar Year.	Value.
1892	$ 150,000
1893	376,233
1894	313,754
1895	423,032
1896	276,301
1897	325,873
1898	322,123
1899	387,271
1900	417,094
1901	339,476
1902	195,992

NICKEL.

NICKEL.

Nickel is one of the most important of the metallic minerals mined in Canada, not only on account of the size and value of the industry, but also because its product constitutes such an important feature in the nickel market of the world. The output, which is derived from the well known nickel-copper ores of the Sudbury district of Ontario, has been increasing very rapidly during the past few years, and has almost doubled since 1899. The total production of nickel in matte in 1902 amounted to 10,693,410 pounds or 5,346 tons valued at $5,025,903 or 47 cents per pound as compared with 9,189,047 pounds or 4,594 tons valued at $4,594,523 or 50 cents per pound in 1901. The increase for the year was 1,504,363 pounds or over 16 per cent. The price of refined nickel at New York, as reported in the Engineering and Mining Journal of that city, ranged during a period from January to July from 50 to 60 cents per pound and from August until the end of the year, quotations were from 40 to 47 cents per pound with small lots selling as high as 60 cents.

The total quantity of nickel-copper ore mined in 1902 was 269,538 tons, while the quantity smelted was 211,847 tons. From the smelted ore there was produced 23,211 tons of ordinary matte, carrying an average of about 19.39 per cent nickel and 11.65 per cent copper, and 2,100 tons of Bessemer matte averaging 40.27 per cent nickel

NICKEL.

Production.

and 40.34 per cent copper. A portion of the ordinary matte above mentioned was further treated at the Works of the Ontario Smelting Co. at Copper Cliff before shipment to the refining plants in the United States.

Besides the product sold by the Canadian Copper Co. and Mond Nickel Co., a considerable tonnage of ore was mined by the Lake Superior Power Co., the greater part of which was sent to roast heaps and a small portion to reduction works at Sault Ste. Marie.

The nickel contents of this ore has not been included in the above statement of the production of nickel in matte etc. for the year.

The companies operating in the Sudbury District are:—

The Canadian Copper Company,

The Mond Nickel Company,

The Lake Superior Power Company,

The Nickel Copper Company of Ontario.

The first two are provided with smelting plants producing nickel copper matte, while the operations of the last two companies may be still said to be in the development stage, so far as the production of matte is concerned.

TABLE 1.

NICKEL.

ANNUAL PRODUCTION.

Calendar Year.	Pounds of Nickel in Matte.	Final Average Market Price per lb. at New York.	Value.
1889	*830,477	60c.	$ 498,286
1890	1,435,742	65c.	933,282
1891	4,626,627	60c.	2,775,976
1892	2,413,717	58c.	1,399,956
1893	3,982,982	52c.	2,071,151
1894	4,907,430	38½c.	1,870,958
1895	3,888,525	35c.	1,360,984
1896	3,397,113	35c.	1,188,990
1897	3,997,647	35c.	1,399,176
1898	5,517,690	33c.	1,820,838
1899	5,744,000	36c.	2,067,840
1900	7,080,227	47c.	3,327,707
1901	9,189,047	50c.	4,5 4,523
1902	10,693,410	47c.	5,025,903

* Calculated from shipments made by rail.

NICKEL.

Exports.

TABLE 2.

NICKEL.

EXPORTS.*

Calendar Year.	Value.	Calendar Year.	Value.
1890	$ 89,568	1897	723,130
1891	667,280	1898	1,019,363
1892	293,149	1899	939,915
1893	629,692	1900	1,031,030
1894	559,356	1901	751,080
1895	521,783	1902	1,007,211
1896	658,213		

*Practically all the nickel-bearing ore and matte produced in Canada is exported, the apparent discrepancy between Tables Nos. 1 and 2 being due to the different basis of valuation adopted in the two instances. Table 1 represents the total final values of the nickel produced in Canada, for the years represented. In Table 2 the worth of the product shipped is entered at its spot value to the operators, and depends upon the particular stage to which they happen to carry the process of extraction at the time, *e.g.*, whether the shipments made are raw ore, low grade matte or high grade matte, &c.

Imports.

TABLE 3.

NICKEL.

IMPORTS.

Calendar Year.		Duty.	Value.
1890			$ 3,154
1891			3,889
1892			3,208
1893			2,905
1894			3,528
1895			4,267
1896			4,787
1897			4,737
1898			5,882
1899			9,449
1900			6,988
1901			12,029
1902	Nickel anodes	10 p. c.	13,909
	Nickel*	Free.	1,539
			$ 15,448

*Classified under the general heading of minerals in the Trade and Navigation Report.

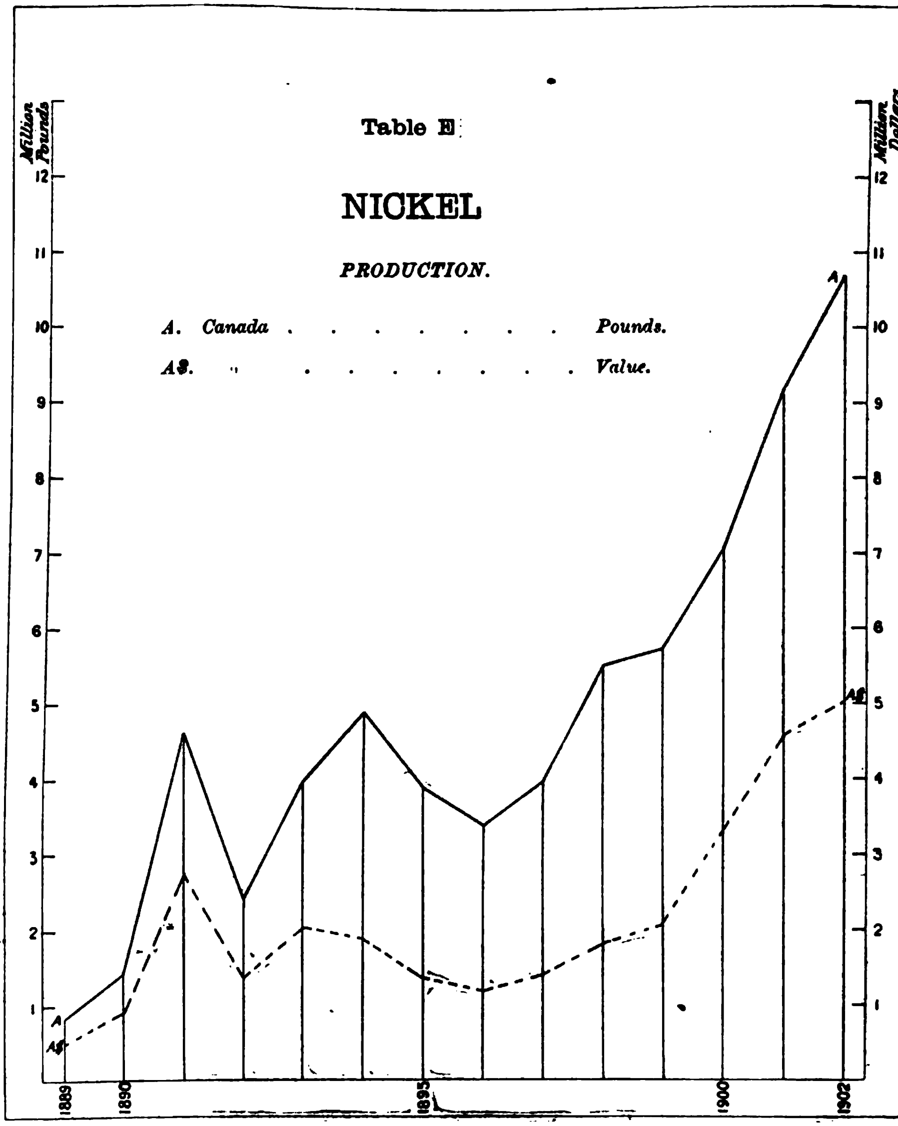


Table E
NICKEL
PRODUCTION.
A. Canada . . . . Pounds.
A$. " . . . . Value.
Million Pounds
Million Dollars
12
11
10
9
8
7
6
5
4
3
2
1
A
A$
1889
1890
1895
1900
1902

PETROLEUM.

PETROLEUM.

Production.

Although numerous attempts have been made during recent years to find petroleum in workable quantities in Gaspé, Quebec, and in Albert and Westmoreland counties, New Brunswick, nevertheless the oil fields at Petrolia and adjacent districts in the southern peninsula of Ontario continue to be the only sources of the Canadian output, and in this field a tendency towards decreased production has been evident during the past couple of years. The greater part of the Canadian product is sent to the refineries at Sarnia and Petrolia, although quite an important quantity is now used for various industrial purposes, such as for fuel, for making gas, &c., returns having been received from nine companies selling crude petroleum for these purposes.

The total production for 1902 has been estimated at 530,624 barrels valued at $951,190, or an average of $1.79½ per barrel, made up as follows :—

	Barrels.
Receipts at refineries	443,333
Direct sale for industrial purposes	87,291
Total sales of crude oil, 1902	530,624

The above estimate is, of course, a minimum, as there may be other firms selling crude oil for industrial purposes from whom returns were not received, however the probabilities are that these would not increase the total very much.

The production for 1901, estimated on a similar basis, was 622,392 barrels valued at $1,008,275, or an average of $1.62 per barrel.

	Barrels.
Receipts at refineries	508,677
Direct sales for industrial purposes	113,715
Total sales of crude oil, 1901	622,392

The decrease in production, therefore, was 91,768 barrels, or a little over 14 per cent. In this connection, however, attention may be called to the fact that the decrease in Canadian refined oils inspected in 1902 as compared with 1901 was over 17 per cent. (See Table 3.) For the year 1900 and previous years, the production of crude oil was estimated from inspection returns by assuming a ratio of crude to refined, and the statistics of production on this basis will

PETROLEUM.

be found in Table 1. The method, however, was open to objection owing to the possible incorrectness of the ratio assumed.

Statistics of the quantities of Canadian and of imported oils inspected, the exports and imports of petroleum and its products and monthly prices of crude oil are shown in the following tables :—

TABLE 1.

PETROLEUM.

CANADIAN OILS AND NAPHTHA INSPECTED AND CORRESPONDING QUANTITIES OF CRUDE OIL.

Calendar Year.	Refined Oils Inspected.	Crude Equivalent Calculated.	Ratio of Crude to Refined.	Equivalent in Barrels of 35 Gallons	Average Price per Barrel of Crude.	Value of Crude Oil.
	Gallons.	Gallons.				
1881	6,457,270	12,914,540	100:50	368,987	....	....
1882	6,135,782	13,635,071	100:45	389,573	....	....
1883	7,447,648	16,550,328	100:45	472,866	....	....
1884	7,993,995	19,984,987	100:40	571,000	....	....
1885	8,225,882	20,564,705	100:40	587,563	....	....
1886	7,768,006	20,442,121	100:38	584,061	$0 90	$525,655
1887	9,492,588	24,980,494	100:38	713,728	0 78	556,708
1888	9,246,176	24,332,042	100:38	695,203	1 02¾	713,695
1889	9,472,476	24,664,144	100:38	704,690	0 92¾	653,600
1890	10,174,894	26,776,037	100:38	795,030	1 18	902,734
1891	10,065,463	26,435,430	100:38	755,298	1 33⅜	1,010,211
1892	10,370,707	27,291,334	100:38	779,753	1 26¼	984,438
1893	10,618,804	27,944,221	100:38	798,406	1 09½	874,255
1894	11,027,082	29,018,637	100:38	829,104	1 00⅝	835,322
1895	10,674,232	25,414,838	100:42	726,138	1 49⅜	1,036,738
1896	10,684,284	25,438,771	100:42	726,822	1 59	1,155,647
1897	10,434,878	24,844,995	100:42	709,857	1 42½	1,011,546
1898	11,148,348	26,543,685	100:42	758,391	1 40	1,061,747
1899	11,927,981	28,399,955	100:42	808,570	1 48⅝	1,202,020
1900	13,428,422	24,867,449	100:54	710,498	1 62	1,151,007

TABLE 2.

PETROLEUM.

VALUE OF THE PRODUCTION OF CANADIAN OIL REFINERIES.

Calendar Year.	Value.	Calendar Year.	Value.
1887	$1,288,109	1895	1,806,237
1888	1,401,459	1896	1,876,913
1889	1,414,184	1897	1,672,429
1890	1,638,420	1898	1,825,265
1891	1,534,509	1899	1,490,870
1892	1,782,365	1900	1,620,705
1893	1,675,784	1901	1,251,373
1894	1,567,134	1902	1,222,641

PETROLEUM.

TABLE 3.

PETROLEUM.

TOTAL AMOUNT OF OIL INSPECTED, CANADIAN AND IMPORTED.

Fiscal Year	Canadian.	Imported.	Total.	Canadian.	Imported.
	Gallons.	Gallons.	Gallons.	Per cent.	Per cent.
1881..........	6,406,783	476,784	6,883,567	93·1	6·9
1882..........	5,910,747	1,351,412	7,262,159	81·4	18·6
1883..........	6,970,550	1,190,828	8,161,378	85·4	14·6
1884	7,656,001	1,142,575	8,798,586	87·0	13·0
1885..........	7,661,617	1,278,115	8,939,732	85·7	14·3
1886.........	8,149,472	1,327,616	9,477,088	86·0	14·0
1887..........	8,243,962	1,665,604	9,909,566	83·2	16·8
1888..........	9,545,895	1,821,342	11,367,237	84·0	16·0
1889..........	9,462,834	1,767,812	11,230,646	84·3	15·7
1890	10,121,210	2,020,742	12,141,952	83·4	16·6
1891..........	10,270,107	2,022,002	12,292,109	83·6	16·4
1892..........	10,238,426	2,429,445	12,667,871	80·8	19·2
1893	10,683,806	2,641,690	13,325,496	80·2	19·8
1894..........	10,824,270	5,633,222	16,457,492	65·8	34·2
1895...... ...	10,936,992	5,650,994	16,587,986	65·9	34·1
1896	10,533,951	5,807,991	16,341,942	64·5	35·5
1897..........	10,506,526	6,248,743	16,755,269	62·7	37·3
1898...	10,796,847	6,880,734	17,677,581	61·1	38·9
1899..........	11,005,804	7,232,348	18,238,152	60·3	39·7
1900..........	13,014,713	*8,216,207	21,230,920	61·3	38·7
1901..........	12,674,977	*9,232,165	21,907,142	57·9	42·1
1902...... ...	10,494,874	*10,916,396	21,411,270	49·0	51·0

* Item (*a*) Table 5.

TABLE 4.

PETROLEUM.

EXPORTS OF CRUDE AND REFINED PETROLEUM.

Calendar Year.	Crude Oil.		Refined Oil.		Total.	
	Gallons.	Value.	Gallons.	Value.	Gallons.	Value.
1881	....	....	....	....	501	$ 99
1882	....	....	....	....	1,119	286
1883	....	....	....	....	13,283	710
1884	....	....	....	....	1,098,090	30,168
1885	....	....	....	....	337,967	10,562
1886	....	....	....	....	241,716	9,855
1887	....	....	....	....	473,559	13,831
1888	....	....	....	....	196,602	74,542
1889	....	....	....	....	235,855	10,777
1890	....	....	....	....	420,492	18,154
1891	446,770	$ 18,471	585	$104	447,355	18,575
1892	310,387	12,945	1,146	100	311,533	13,045
1893	107,719	3,696	2,196	394	109,915	4,090
1894	53,985	2,773	5,297	513	59,282	3,286
1895	22,831	1,044	10,237	2,023	33,068	3,067
1896	601	101	7,489	999	8,090	1,100
1897	....	....	342	49	342	49
1898	96	4	12,735	3,001	12,831	3,005
1899	....	....	3,425	859	3,425	859
1900	40	2	8,559	2,394	8,599	2,396
1901	14,168	691	375	66	14,543	757
1902	400	40	626	146	1,026	186

PETROLEUM.

Imports.

TABLE 5.

PETROLEUM.

IMPORTS OF PETROLEUM AND PRODUCTS OF.

Fiscal Year.	Gallons.	Value.
		$
1880	687,641	131,359
1881	1,437,475	262,168
1882	3,007,702	398,031
1883	3,086,316	358,546
1884	3,160,282	380,082
1885	3,767,441	415,195
1886	3,819,146	421,836
1887	4,290,003	467,003
1888	4,523,056	408,025
1889	4,650,274	484,462
1890	5,075,650	515,852
1891	5,071,386	498,330
1892	5,649,145	475,732
1893	6,002,141	446,389
1894	6,597,108	439,988
1895	7,577,674	525,372
1896	8,005,891	735,913
1897	8,415,302	697,169
1898	9,074,311	724,519
1899	10,394,208	763,303
1900	9,633,647	864,833
1901	11,082,822	982,640

		Duty.	Gallons.	Value.
1902	Oils:— Mineral:			
	(a) Coal and kerosene, distilled, purified or refined, naphtha and petroleum, N.E.S.	5c. p. gall.	10,916,396	$878,087
	(b) Products of petroleum	5c. "	491,106	52,285
	(c) Crude petroleum, fuel and gas oils (other than naphtha, benzine or gasoline) when imported by manufacturers (other than oil refiners) for use in their own factories, for fuel purposes or for the manufacture of gas	2½c. "	591,328	40,568
	(d) Illuminating oils composed wholly or in part of the products of petroleum, coal, shale or lignite, costing more than 30 cents per gallon	25 p. c.	7,256	2,541
	(e) Lubricating oils composed wholly or in part of petroleum, costing less than 25 cents per gallon	5c. p. gall.	1,213,919	133,726
	Total		13,220,005	1,107,207

PETROLEUM.

Imports.

TABLE 6.*

PETROLEUM.

IMPORTS OF CRUDE AND MANUFACTURED OILS, OTHER THAN ILLUMINATING.

Fiscal Year	Gallons.	Fiscal Year.	Gallons,
1881	960,691	1892	3,047,199
1882	1,656,290	1893	1,481,749
1883	1,895,488	1894	1,860,829
1884	2,017,707	1895	1,106,993
1885	2,489,326	1896	1,079,965
1886	2,491,530	1897	802,286
1887	2,624,399	1898	1,047,026
1888	2,701,714	1899	1,017,278
1889	2,882,462	1900	1,406,700
1890	3,054,908	1901	1,838,966
1891	3,049,384	1902	2,296,353

* The figures for the years from 1881 to 1894, inclusive, represent the total imports of petroleum and products, less the quantity of imported illuminating oils, inspected by the Inland Revenue Department. For 1895 and subsequent years, the Table is composed of items (*b*), (*c*) and (*e*) of Table 5.

TABLE 7.

PETROLEUM.

IMPORTS OF PARAFFINE WAX.

Fiscal Year.	Pounds.	Value.
1883	43,716	$ 5,166
1884	39,010	6,079
1885	59,967	8,123
1886	62,035	7,953
1887	61,132	6,796
1888	53,862	4,930
1889	63,229	5,250
1890	239,229	15,844
1891	753,854	50,275
1892	733,873	48,776
1893	452,916	38,935
1894	208,099	15,704
1895	163,817	11,579
1896	150,287	10,042
1897	138,703	7,945
1898	103,570	5,987
1899	92,242	4,025
1900	47,400	3,529
1901	118,848	9,639
1902...(Duty, 30 p. c.)	225,885	12,750

PETROLEUM.

Imports.

TABLE 8.

PETROLEUM.

IMPORTS OF PARAFFINE WAX CANDLES.

Fiscal Year.	Pounds.	Value.
1880	10,445	$2,269
1881	7,494	1,683
1882	5,818	1,428
1883	7,149	1,734
1884	8,755	2,229
1885	9,247	2,449
1886	12,242	2,587
1887	21,364	3,611
1888	22,054	2,829
1889	8,038	1,337
1890	7,233	1,186
1891	10,598	2,116
1892	9,259	1,952
1893	8,351	1,735
1894	10,818	1,685
1895	19,448	2,541
1896	25,787	4,072
1897	25,114	2,929
1898	60,802	4,427
1899	62,331	5,856
1900	27,663	3,671
1901	44,562	3,588
1902..(Duty, 30 p.c.)	51,120	5,752

Prices.

TABLE 9.

PETROLEUM.

AVERAGE MONTHLY PRICES FOR CRUDE OIL AT PETROLIA DURING YEAR 1902.

MONTH.	PRICE.	MONTH.	PRICE.
January	$1 61 to $1 68	July	$1 76 to $1 83
February	1 61 to 1 68	August	1 76 to 1 83
March	1 61 to 1 68	September	1 76 to 1 83
April	1 63½ to 1 70½	October	1 82 to 1 89½
May	1 66 to 1 73	November	1 92 to 2 01½
June	1 68½ to 1 78	December	1 96 to 2 04½
		The Year	1 79¾

PHOSPHATE.

PHOSPHATE.

The production of phosphate in 1902 according to returns received from operators, was 856 tons valued at $4,953. About 530 tons of this was high grade ore (80 per cent) and used for the manufacture of phosphorus the balance being sold as a fertilizer. The output is practically all obtained as a by-product in the mining of mica in the counties of Wright and Labelle near Ottawa.

TABLE 1.

PHOSPHATE.

ANNUAL PRODUCTION.

Production.

Calendar Year.	Tons.	Average Value per ton.	Value.
1886	20,495	$14 85	$304,338
1887	23,690	13 50	319,815
1888	22,485	10 77	242,285
1889	30,988	10 21	316,662
1890	31,753	11 37	361,045
1891	23,588	10 24	241,603
1892	11,932	13 20	157,424
1893	8,198	8 65	70,942
1894	6,861	6 00	41,166
1895	1,822	5 25	9,565
1896	570	6 00	3,420
1897	908	4 39	3,984
1898	733	5 00	3,665
1899	3,000	6 00	18,000
1900	1,415	5 02	7,105
1901	1,033	6 07	6,280
1902	856	5 79	4,953

PHOSPHATE.

Exports.

TABLE 2.

PHOSPHATE.

EXPORTS.

Calendar Year.	Ontario.		Quebec.		Totals.	
	Tons.	*Value.	Tons.	*Value.	Tons.	*Value.
1878	824	$12,278	9,919	$195,831	10,743	$208,109
1879	1,842	20,565	6,604	101,470	8,446	122,035
1880	1,387	14,422	11,673	175,664	13,060	190,086
1881	2,471	36,117	9,497	182,339	11,968	218,456
1882	568	6,338	16,585	302,019	17,153	308,357
1883	50	500	19,666	427,168	19,716	427,668
1884	763	8,890	20,946	415,350	21,709	424,240
1885	434	5,962	28,535	490,331	28,969	496,293
1886	644	5,816	19,796	337,191	20,460	343,007
1887	705	8,277	22,447	424,940	23,152	433,217
1888	2,643	30,247	16,133	268,362	18,776	298,609
1889	3,547	38,833	26,440	355,935	29,987	394,768
1890	1,866	21,329	26,591	478,040	28,457	499,369
1891	1,551	16,646	15,720	368,015	17,271	384,661
1892	1,501	12,544	9,981	141,221	11,482	153,765
1893	1,990	11,550	5,748	56,402	7,738	67,952
1894	1,980	10,560	3,470	29,610	5,450	40,170
1895	......	......	250	2,500	250	2,500
1896	1	5	299	2,990	300	2,995
1897	70	450	165	400	235	850
1898	21	240	702	8,000	723	8,240
1899	215	1,850	93	1,725	308	3,575
1900	......	......	......	......	Nil	Nil
1901	......	......	......	......	6	120
1902	......	......	......	......	70	1,880

* These values do not compare with those in Table 1 above; the spot value is adopted for the production whilst the exports are valued upon quite a different basis.

PLATINUM.

PLATINUM.

There was a small production of platinum in 1902, valued at $190, and obtained entirely from the Similkameen district of British Columbia. This is the only locality where the metal is saved.

For a description and list of occurrence of platinum in Canada, reference may be made to the report of this Section for 1901, pages 97-110.

PLATINUM.

Production.

TABLE 1.

PLATINUM.

ANNUAL PRODUCTION OF PLATINUM.

Calendar Year.	Value.	Calendar Year.	Value.
1887	$ 5,600	1895	3,800
1888	6,000	1896	750
1889	3,500	1897	1,600
1890	4,500	1898	1,500
1891	10,000	1899	825
1892	3,500	1900	Nil.
1893	1,800	1901	457
1894	950	1902	190

Imports.

TABLE 2.

PLATINUM.

IMPORTS OF PLATINUM.

Fiscal Year.	Value.	Fiscal Year.	Value.
1883	$ 113	1893	14,082
1884	576	1894	7,151
1885	792	1895	3,937
1886	1,154	1896	6,185
1887	1,422	1897	9,031
1888	13,475	1898	9,781
1889	3,167	1899	9,671
1890	5,215	1900	57,910
1891	4,065	1901	20,263
1892	1,952	1902*	19,357

* Platinum wire and platinum in bars, strips, sheets or plates, platinum retorts, pans, condensers, tubing and pipe, imported by manufacturers of sulphuric acid for use in their works. Duty free.

Some additional information concerning the occurrences of platinum in British Columbia has been published in the Annual Report for 1902 of the Minister of Mines of that province, and is quoted hereunder.

"It has long been recognized as a fact that platinum and sometimes its related metals, occur associated with the placer gold of the various parts of the province. With an idea of locating the source of these metals the Provincial Mineralogist secured a number of samples of black sands from various parts of Cariboo, and these have been analysed by the Provincial Assayer, whose results will be found embodied in the table following, in which the locality from which the samples

PLATINUM.

British Columbia.

were derived is also given. From this it will be seen, that the distribution of the metals is wide, a fact which has so far defeated the attempt to locate their source, but the investigation will be continued.

Locality of samples of black sand.	Assay value per ton.			
	Gold, oz.	Silver, oz.	Platinum, oz.	Osmiridium, oz.
Head of Harvey Creek.......	....	....	None.....	....
Upper Cunningham Creek...	....	....	"	....
Fraser Creek, Horsefly.......	....	....	"	....
Eureka Creek, Horsefly.	....	....	"	....
Cottonwood Creek...	....	....	"	....
Keithley Creek, (Hayward claim) black sand and pyrites.	5.9..	2.0 ...	" ..	....
Quesnel River, 82 miles above mouth....................	3.8..	Not determined	1	....
Quesnel River, 40 miles above mouth	1.0..	"	2.8.....	....
Quesnel River, 40 miles above mouth....................	0.06.	"	0 14..	....
Quesnel River, 25 miles from mouth....................	0.2..	"	0.4.....	....
Quesnel River, 13 miles above Quesnel	4.7..	"	7.8.....	....
†Quesnel River, 30 miles above Quesnel....................	....	"	6.4.....	....
†Fraser River, 2 miles above Quesnel....................	....	"	2.4.....	....
Quesnel River, 25 miles below Forks....................	1.0..	Trace......	0.5.....	....
Quesnel River, 25 miles below Forks....................	2.5.	"	2.5.....	....
Three miles above Quesnel ...	0.85.	Not determined	0.25....	3.2
*Quesnelmouth (concentrates).	7.1%	"	71%	3.1%
Consolidated Cariboo Hyd. Mg. Co..............	....	....	70%	3.5%
‡Horsefly River, Harpers Camp	....	....	25%	4.5%
Fraser River, 15 miles above Quesnel....................	121.8..	Not determined	3.9. ...	....
Cobeldick dredge, Quesnel Fraser River....................	913....	"	165.7.....	....

† Mostly platinum. Other metals not assayed.

* $\frac{1}{16}$ oz. of mineral giving:—Gold, 0.05 oz. troy; platinum, 0.5 oz. troy; osmiridium, 0.022 oz. troy.

‡ Mr. Hobson says that this platinum is found in the proportion of one ounce platinum to 100 ounces gold.

"From this it will be noted that platinum occurs throughout the drainage area of the Quesnel river, but that it is also found on the Fraser above Quesnelmouth, and that it follows the Fraser down to Lytton. The samples obtained do not indicate its presence in the Barkerville district, though samplings from this section may reveal it."

PRECIOUS METALS.

PRECIOUS METALS.

The precious metals, gold and silver, following the custom of past years, are considered together.

GOLD.

Gold.

The value of the gold mined in Canada in 1902 was $21,336,667. This is less than the production in the two preceeding years, the decrease from the output in 1901 being $2,791,836 or 11·5 per cent. The maximum production of gold in Canada was obtained in 1900, when the total was $27,908,153.

The increase in production from 1896 to 1900 was very rapid due to the larger output from the Yukon placers. The falling off in the production for 1901 and 1902 is also to be ascribed to a decreasing output from the same district which had reached its maximum in 1900.

Of the total production in 1902, $15,588,213, that is, over 73 per cent was placer gold, of which nearly 70 per cent represents the Yukon output. The balance, $5,748,454, or nearly 27 per cent, was derived from lode mines, and of this, nearly 23 per cent was contributed by British Columbia. British Columbia and the Yukon district together produced about 96 per cent of the total output.

Statistics of the total production in Canada and the various provinces are shown in the following tables.

TABLE 1.

PRECIOUS METALS.

GOLD.—ANNUAL PRODUCTION IN CANADA.

Production.

Calendar Year.	*Ounces. Fine.	Value.	Calendar Year.	*Ounces. Fine.	Value.
1887..........	57,465	$ 1,187,804	1895	100,806	2,083,674
1888..........	53,150	1,098,610	1896..........	133,274	2,754,774
1889..........	62,658	1,295,159	1897	291,582	6,027,016
1890..........	55,625	1,149.776	1898..........	666,445	13,775,420
1891..........	45,022	930,614	1899..........	1,028,620	21,261,584
1892..........	43,909	907,601	1900..........	1,350,176	27,908,153
1893..........	47,247	976,603	1901	1,167,320	24,128,503
1894..........	54,605	1,128,688	1902..........	1,032,253	21,336,667

* Calculated from the value at the rate of $20.67 per ounce.

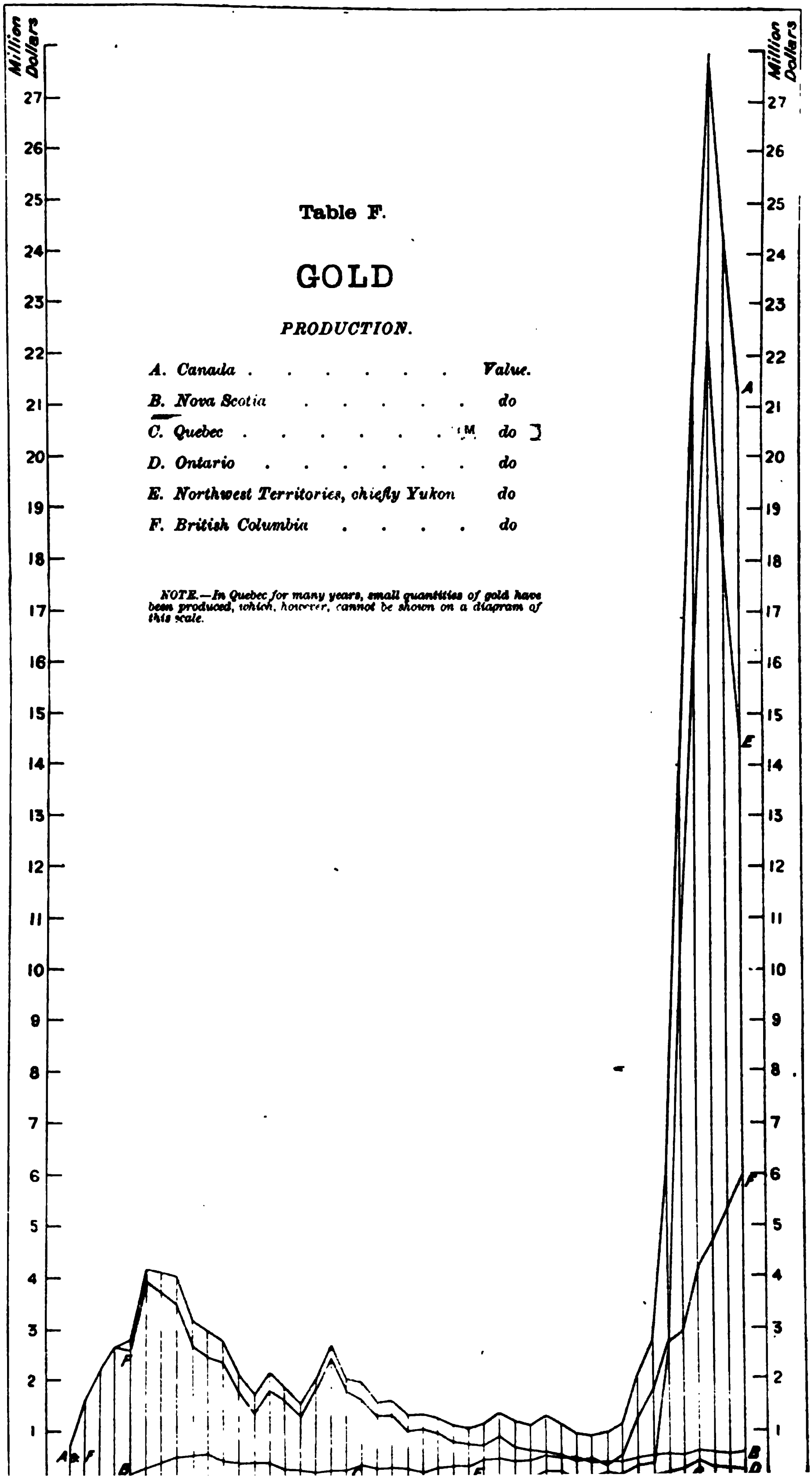

Million Dollars
Table F.
GOLD
PRODUCTION.
A. Canada . . . . Value.
B. Nova Scotia . . . . . . do
C. Quebec . . . . do
D. Ontario . . . . do
E. Northwest Territories, chiefly Yukon do
F. British Columbia . . . . . do
NOTE.—In Quebec for many years, small quantities of gold have been produced, which, however, cannot be shown on a diagram of this scale.
27
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1

TABLE 2.

PRECIOUS METALS.

GOLD.—PRODUCTION BY PROVINCES AND DISTRICTS, CALENDAR YEAR 1902.

PRECIOUS METALS.
Gold.
Production.

Provinces.		*Ounces. Fine.	Value.
Nova Scotia	(b)	30,351	$ 627,357
Quebec	(d)	390	8,073
Ontario	(b)	11,119	229,828
North-west Territories—			
Yukon District	(a)	701,500	14,500,000
Saskatchewan river	(a)	484	10,000
British Columbia	(c)	288,409	5,961,409
Total		1,032,253	$21,336,667

* Calculated from the value at the rate of $20.67 per ounce.
(a) Placer gold.
(b) Gold from vein mining.

(c) As follows: Gold from placer mining			$1,073,140
"	vein	"	4,888,269
			$5,961,409
(d) As follows; Gold from placer mining			$ 5,073
"	vein	"	3,000
			$ 8,073

NOVA SCOTIA.— Nova Scotia.

The gold output of Nova Scotia is obtained entirely from quartz veins. In 1902 there were mined and crushed 93,842 tons of ore containing 30,679 oz., 15 dwts. of gold valued at $627,357 an average of 6 oz., 13 dwts. or $6.68 per ton. This is the largest output recorded in the tables.

The statistics of production are given in Tables 3, 4, 5 and 6 following. Table 3 shows the annual gold output, Table 4 the tons of quartz crushed, and the average yield per ton. Table 5 shows the total product of each district from 1862 to the end of 1902 as well as the average yield per ton, and Table 6 shows the amount of ore crushed and the yield per district for 1902.

PRECIOUS METALS.

Gold.

Nova Scotia.

TABLE 3.

PRECIOUS METALS.

GOLD.—NOVA SCOTIA:—ANNUAL PRODUCTION.

Calendar Year.	Value.	Calendar Year	Value.
1862	$141,871	1883	$301,207
1863	272,448	1884	313,554
1864	390,349	1885	432,971
1865	496,357	1886	455,564
1866	491,491	1887	413,631
1867	532,563	1888	436,939
1868	400,555	1889	510,029
1869	348,427	1890	474,990
1870	387,392	1891	451,503
1871	374,972	1892	389,965
1872	255,349	1893	381,095
1873	231,122	1894	389,338
1874	178,244	1895	453,119
1875	218,629	1896	493,568
1876	233,585	1897	562,165
1877	329,205	1898	538,590
1878	245,253	1899	617,604
1879	268,328	1900	598,553
1880	257,823	1901	546,963
1881	209,755	1902	627,357
1882	275,090		

TABLE 4.

PRECIOUS METALS.

GOLD.—NOVA SCOTIA: ORE TREATED AND YIELD OF GOLD PER TON.

Calendar Year.	Tons Treated.	Yield of Gold per Ton.	Calendar Year.	Tons Treated.	Yield of Gold per Ton.
1862	6,473	$21·91	1883	25,954	$11·60
1863	17,000	16·02	1884	25,186	12·44
1864	21,431	18·21	1885	28,890	14·98
1865	24,421	20·32	1886	29,010	15·70
1866	32,157	15·28	1887	32,280	12·81
1867	31,384	16·96	1888	36,178	12·08
1868	32,259	12·41	1889	39,160	13·02
1869	35,144	19·91	1890	42,749	11·11
1870	30,824	12·56	1891	36,351	12·42
1871	30,787	12·17	1892	32,552	11·98
1872	17,089	14·94	1893	42,354	8·99
1873	17,708	13·05	1894	55,357	7·04
1874	13,844	12·87	1895	60,600	7·47
1875	14,810	14·76	1896	69,169	7·13
1876	15,490	15·08	1897	73,192	7·68
1877	17,369	18·95	1898	82,774	6·50
1878	17,989	13·63	1899	112,226	5·50
1879	15,936	16·83	1900	87,390	6·85
1880	13,997	18·42	1901	91,948	5·32
1881	16,556	12·66	1902	93,842	6·68
1882	21,081	13·04			

PRECIOUS METALS.
Gold.
Nova Scotia.

TABLE 5.

PRECIOUS METALS.

GOLD.—NOVA SCOTIA :—PRODUCTION OF THE DIFFERENT DISTRICTS FROM 1862 TO 1902 INCLUSIVE.

Districts.	Tons of Ore Crushed.	Total Yield.				Average Yield per Ton of 2,000 lbs.
		Oz.	Dwt.	Grs.	Value at $19.00 per oz.	
					$	$ c.
Brookfield	66,949	33,018	2	23	627,344	9·37
Caribou	147,995	48,633	8	11	924,035	6·24
Central Rawdon	13,340	10,121	11	21	192,310	14·42
Fifteen Mile Stream..	40,280	18,132	13	5	344,521	8·55
Lake Catcha.........	17,810	14,473	19	21	275,006	15·44
Malaga..............	24,737	17,486	2	4	332,236	13·43
Montague	25,979	40,045	7	11	760,862	29 29
Oldham............ .	50,309	53,908	10	22	1,024,262	20·36
Renfrew............	50,965	43,541	12	1	827,291	16·23
Salmon River	1 3,602	33,898	6	21	644,068	6·22
Sherbrooke..........	279,653	153,263	1	13	2,911,998	10·41
Stormont.....	279,479	84,500	15	3	1,605,515	5·74
Tangier......	38,257	22,498	5	2	427,467	11·17
Uniacke.............	61,256	41,979	—	5	797,601	13.02
Waverly............	148,079	68,961	8	7	1,310,267	8·85
Wine Harbour.......	58,674	36,302	5	6	689,743	11·76
Other districts.......	108,441	74,541	15	6	1,416,294	13·06
	1,515,804	795,306	6	14	15,110,820	9·97

TABLE 6.

PRECIOUS METALS.

GOLD.—NOVA SCOTIA :—DISTRICT DETAILS, CALENDAR YEAR, 1902.

Districts.	Mines.	Mills.	Tons of Ore Crushed.	Total Yield of Gold.			Average Yield of Gold per Ton.		
				Oz.	Dwt.	Grs.	Oz.	Dwt.	Grs.
Brookfield	1	1	6,475	4,962	9	1	..	15	8
Caribou	4	3	10,959	2,674	15	14	..	4	21
Lake Catcha...........	2	2	792	553	11	23	..	14	..
Malaga Barrens	1	1	120	224	19	..	1	13	8
Montague.............	2	1	101	39	17	11	..	7	15
Oldham...............	3	1	772	614	17	12	..	15	22
Renfrew..............	2	1	1,020	1,672	15	13	1	12	19
Sherbrooke............	3	2	15,521	4,785	16	..	..	6	4
Stormont.............	5	3	34,070	5,749	18	6	..	3	9
Uniacke............. .	3	2	3,064	1,990	4	21	..	13	0
Waverly	2	1	9,089	2,848	18	16	..	6	6
Wine Harbour.........	2	2	3,339	879	12	..	..	5	6
Other districts....... ...	8	6	8,520	3,681	19	3	.	8	14
Total..	38	26	93,842	30,679	15	..	..	6	13

Precious Metals.

Gold.

Quebec.

QUEBEC.—

The production of gold in the province of Quebec in 1902 was about $8,073, made up of $5,073 obtained from the placer workings in the county of Beauce, and $3,000 recovered from the pyrites mined primarily as sulphur ores in the Eastern Townships.

The Gilbert River Gold Fields Co. operated on lot 14 DeLery range, and has introduced an underground haulage system with cage and cars. The company reports the ground worked as being very pockety the gold being found only in vicinities where quartz veins were present in bed rock, while most of the gold was recovered from the dirt overlying a blue vein of quartz.

TABLE 7.

PRECIOUS METALS.

GOLD.—QUEBEC:—ANNUAL PRODUCTION.

Calendar Year.	Value.	Calendar Year.	Value.
1877	$12,057	1890	$1,350
1878	17,937	1891	1,800
1879	23,972	1892	12,987
1880	33,174	1893	15,696
1881	56,661	1894	29,196
1882	17,093	1895	1,281
1883	17,787	1896	3,000
1884	8,720	1897	900
1885	2,120	1898	6,089
1886	3,981	1899	4,916
1887	1,604	1900	Nil.
1888	3,740	1901	3,000
1889	1,207	1902	8,073

Ontario.

ONTARIO—

The production of gold in Ontario in 1902, according to the figures published by the Ontario Bureau of Mines, was $229,828, a slight falling off from the production of the previous year. Over $100,000 of this output was obtained from three mines in the townships of Marmora and Belmont in eastern Ontario, the balance being derived from about six or seven mines in the north-western part of the province.

Statistics of production since 1887 are given below.

PRECIOUS METALS.

Gold.

Ontario.

TABLE 8.

PRECIOUS METALS.

GOLD.—ONTARIO:—ANNUAL PRODUCTION.

Calendar Year.	*Ounces. Fine.	Value.
1887	327	$ 6,760
1888	....	....
1889	....	....
1890	....	....
1891	97	2,000
1892	344	7,118
1893	708	14,637
1894	1,917	39,624
1895	3,015	62,320
1896	5,563	115,000
1897	9,158	189,294
1898	12,864	265,889
1899	20,395	421,591
1900	14,392	297,495
1901	11,845	244,837
1902	11,119	229,828

* Calculated from the value at the rate of $20·67 per ounce.

NORTH-WEST TERRITORIES.

North-west Territories.

The production of gold from the placer workings of the Yukon district in 1902 estimated as it was during the past few years, on the basis on the receipts of Canadian Yukon gold at United States mints was $14,500,000.

This is somewhat higher than the value on which royalty was paid, and also more than the Customs department have record of as being exported.

The exports from Dawson and White Horse of which returns were received, amounted to a total of about $12,128,415, while royalty was collected on an output of $12,018,561. Due allowance must be made however for gold which escapes the payment of royalty, and it must also be remembered that for the purposes of the royalty the gold is given a nominal value of $15 an ounce which is probably somewhat less than the average value of the gold obtained.

PRECIOUS METALS.

Gold.

North-west Territories.

TABLE 9.

PRECIOUS METALS.

GOLD.—NORTH-WEST TERRITORIES :—PRODUCTION.

Calendar Year.	Yukon District.		Saskatchewan River.	
	*Ounces. Fine.	Value.	*Ounces Fine.	Value.
		$		$
1885 } 1886 }	4,838	100,000	....	....
1887	3,387	70,000	102	2,100
1888	1,935	40,000	58	1,200
1889	8,466	175,000	968	20,000
1890	8,466	175,000	194	4,000
1891	1,935	40,000	266	5,500
1892	4,233	87,500	508	10,506
1893	8,515	176,000	466	9,640
1894	6,047	125,000	725	15,000
1895	12,095	250,000	2,419	50,000
1896	14,514	300,000	2,661	55,000
1897	120,948	2,500,000	2,419	50,000
1898	483,793	10,000,000	1,209	25,000
1899	774,069	16,000,000	726	15,000
1900	1,077,649	22,275,000	242	5,000
1901	870,827	18,000,000	726	15,000
1902	701,500	14,500,000	484	10,000
Total	4,103,217	84,813,500	14,173	292,946

*Calculated from the value at the rate of $20.67 per ounce.

A statement compiled in the Timber and Mines branch, and published in the report of the Department of the Interior showing the total gold production, the total exemption, the total amount upon which the royalty was collected and the amount of royalty paid, as shown by returns from May 1st, 1898, to June 30th, 1901, is given below. Comparison with Table No. 9 will show that quite a large proportion of the Yukon output escaped the royalty dues.

Precious Metals.

Gold.

North-west Territories.

Month.	Total Gold Production.	Total Exemption.	Royalty Collected on.	Royalty Paid.
1898.	$ cts.	$ cts.	$ cts.	$ cts.
May	45,277 00	10,850 00	34,427 00	3,442 70
June	3,027,496 20	342,550 00	2,698,501 20	269,850 12
Two months	3,072,773 20	353,400 00	2,732,928 20	273,292 82
July	928,818 00	135,000 00	793,818 00	79,381 80
August	395,045 50	140,000 00	255,045 50	25,504 55
September	251,547 70	64,540 00	187,007 70	18,700 75
October	13,669 65	2,496 00	11,173 65	1,117 37
November	4,851 56	2,912 00	1,939 56	193 95
December	8,719 55	624 00	8,095 55	809 55
Six months	1,602,651 96	345,572 00	1,257,079 96	125,707 97
1899.				
January	6,552 76	4,784 C0	1,768 76	176 94
February	4,868 29	624 00	4,244 29	424 41
March	15,431 40	3,952 00	11,479 40	1,147 93
April	43,889 57	15,400 00	28,489 57	2,848 92
May	844,606 18	180,703 00	663 903 18	66,390 28
June	5,064,282 86	1,148,622 02	3,915,660 84	391,565 92
Six months	5 979,631 06	1,354,085 02	4,625,546 04	462,554 40
July	664,205 72	208,380 82	455,824 90	45,582 49
August	1,521,708 96	311,740 16	1,209,968 80	120,996 88
September	924,907 09	187,413 99	737,493 10	73,749 31
October	371,947 82	63,863 02	308,084 80	30,808 48
November	176,599 48	29,088 48	147,511 00	14,751 10
December	84,531 76	31.976 26	52,555 59	5,255 55
Six months	3,743,900 83	832,462 73	2,911,438 10	291.143 81
1900.				
January	....	....	....	....
February	42,179 62	19,333 22	22,846 40	2,284 64
March	96,968 23	42,500 33	54,467 90	5,446 79
April	59,839 70	21,667 80	38,171 90	3,817 19
May	796,866 25	313,642 65	483,223 60	48,322 36
June	5,069,710 01	1,272,137 91	3,797,572 10	379,757 21
Six months	6,065,563 81	1,669,281 91	4,396,281 90	439,628 19
July	2,346,440 64	410,399 99	1,936,040 65	193,707 36
August	1,354,543 88	137,500 00	1,219,148 10	121,914 81
September	1,012,731 48	91,100 00	921,630 90	92,163 09
October	378,991 50	40,000 00	338,990 17	31,772 73
November	63,591 79	38,500 00	25,091 79	2,509 15
December	14,595 47	....	14,595 47	1,459 54
Six months	5,170,894 76	717,499 99	4,455,497 08	443,526 68

PRECIOUS METALS.

Gold.

North-west Territories.

MONTH.	Total Gold Production.	Total Exemption.	Royalty Collected on.	Royalty Paid.
1901.	$ cts.	$ cts.	$ cts.	$ cts.
January	28,486 81	10,000 00	18,486 81	1,832 65
February	34,923 53	10,000 00	24,923 53	2,492 34
March	13,651 91	2,500 00	11,151 91	1,115 23
April	65,156 32	5,000 00	60,156 32	6,015 63
May	183,953 75	40,833 33	143,119 67	10,728 39
June	3,665,015 71	1,141,833 30	2,523,182 41	126,950 06
Six months	3,991,188 03	1,210,166 63	2,781,020 65	149,134 30

The totals of the above items for the fiscal years are as follows :—

Fiscal Year.	Total Gold Production.	Total Exemption.	Royalty Collected on.	Royalty Paid.
	$	$	$	$
1898	3,072,773	339,845	2,732,928	273,292
1899	7,582,283	1,699,657	5,882,626	588,262
1900	9,809,464	2,501,744	7,307,720	730,771
1901	9,162,082	1,927,666	7,236,522	592,660
1902	9,566,340	1,199,114	8,367,225	331,436

British Columbia.

BRITISH COLUMBIA.—

The total value of the gold produced in this province in 1902 was $5,961,409, being an increase over the production in 1901 of about 12 per cent. Nearly $1,073,140 or 18 per cent of the whole was obtained from the placer workings and $4,888,269 or 82 per cent from the lode mines.

Statistics of the yearly production of this province since 1858 are given in Table 10, and detailed statistics of the production by districts are shown in Table 11.

The Provincial Mineralogist in his report to the Minister of Mines for the Province, gives the following summarized description of the progress made in gold mining in 1902.

Placer Gold Mining.—The placer gold output for 1902 was $1,073,140, an increase of $103,040 over the preceding year. It is to the small partnerships and individual miners that is due, not only the present increase, but the prevention of what promised to be a serious deficit, inasmuch as the large companies have this year made compara-

tively poor outputs, for reasons explained later. As an illustration of this fact, the Gold Commissioner of Atlin reports that out of a total sum on which royalty was collected of $261,985, some $190,652 was produced by the small or individual concerns, and only some $71,162 was produced by the larger companies. This statement is even stronger than appears on the face of it, inasmuch as it far easier to collect royalty from companies, and it is highly probably that as much as $100,000 produced by individuals escaped taxation.

PRECIOUS METALS. Gold. British Columbia.

"This is also equally true of the Cariboo District, for in the Omineca division only small concerns were at work this past year of 1902, yet the output of gold was about double that of 1901. In the Cariboo division there were produced some $60,000 over the previous year, and this amount is certainly due to the small concerns, as the big companies made little production during 1902. There is in this division, however, a number of small companies or partnerships, the efforts of which have been very successful during the past year. In the Quesnel division in which the yearly output is chiefly made up from the product of one or two large companies, there has been this year a decrease of about $80,000, due to the falling off in production of these companies, while the product of the individual miner remains about constant."

TABLE 10.

PRECIOUS METALS.

GOLD.BRITISH COLUMBIA: —ANNUAL PRODUCTION.

Calendar Year.	Value.	Calendar Year.	Value.
1858	$ 705,000	1881	1,046,737
1859	1,615,072	1882	954,085
1860	2,228,543	1883	794,252
1861	2,666,118	1884	736,165
1862	2,656,903	1885	713,738
1863	3,913,563	1886	903,651
1864	3,735,850	1887	693,709
1865	3,491,205	1888	616,731
1866	2,662,106	1889	588,923
1867	2,480,868	1890	494,436
1868	2,372,972	1891	429,811
1869	1,774,978	1892	399,525
1870	1,336,956	1893	379,535
1871	1,799,440	1894	530,530
1872	1,610,972	1895	1,266,954
1873	1,305,749	1896	1,788,206
1874	1,844,618	1897	2,724,657
1875	2,474,904	1898	2,939,852
1876	1,786,648	1899	4,202,473
1877	1,608,182	1900	4,732,105
1878	1,275,204	1901	5,318.703
1879	1,290,058	1902	5,961,409
1880	1,013,827		

PRECIOUS METALS.

Gold.

British Columbia.

TABLE 11.

PRECIOUS METALS.

GOLD:—BRITISH COLUMBIA.—PRODUCTION BY DISTRICTS—1902.

Districts.	Gold, Placer.		Gold, Lode.	
	Ounces.	Value.	Ounces.	Value.
		$		$
Cariboo:				
Cariboo division	17,000	340,000	19	393
Quesnel "	8,000	160,000	.....	.....
Omineca "	2,000	40,000	.....	.....
Cassiar:				
Atlin Lake division	20,000	400,000	.....	.....
All other divisions	800	16,000	474	9,797
East Kootenay:				
Fort Steele division	1,650	33,000	.....	.....
Other divisions	.....	.....	16	331
West Kootenay:				
Ainsworth division	.....	.....	5	103
Nelson "	.....	.....	25,116	519,148
Slocan "	.....	.....	353	7,297
Trail Creek "	.....	.....	162,146	3,351,558
All other divisions	100	2,000	652	13,477
Lillooet	1,372	27,440	193	3,989
Yale:				
Grand Forks &c	250	5,000	42,745	883,539
Similkameen division	135	2,700	.....	.....
Yale "	2,350	47,000	6	124
Coast and other districts	.....	.....	4,766	98,513
Total	53,657	1,073,140	236,491	4,888,269

"As to the placer gold output of the remainder of the province it is almost exclusively produced by partnerships or individuals.

"*Hydraulicing.*—The past year has not been a successful one for the hydraulic miner, from causes entirely beyond the control of man. For instance, the largest hydraulic company in the province, the Consolidated Cariboo, this past year had only water sufficient to run 66 days and to move 690,442 cubic yards of earth producing $61,395 in gold; while the previous year there was water for 104 days, and 2,420,288 cubic yards were moved, producing $142,274 in gold. The watershed from which this water was collected was the same as in the previous year, and it is simply a case of insufficient rainfall. The rainfall for some three or four years past has been getting less each year, although it must be pointed out that this state of affairs is not expected to con-

tinue, for it seems that such occurrences run in cycles, and that a period of greater rainfall is now almost due. The output then, of such a company as this, with a given plant, seems to be very nearly in direct proportion to the precipitation on the watershed.

PRECIOUS METALS. Gold. British Columbia.

"In the Atlin district, the report of the Gold Commissioner as to gold produced, indicates that the hydraulic companies have not yet really settled down to business, and the hope entertained of a large output from this quarter is again deferred for another year. The Thibert creek company's property, in the Liard mining division, gave promise this year of being a considerable producer, but this hope was frustrated by a tremendous clayslide, which practically buried the pit. This slide has now been removed, and the gold should be recovered next year.

"The auriferous black sands found on the coast at various points, have not been productive this year, for reasons unknown.

"*Dredging.*—Dredging for gold has not received the usual amount of attention this past year, only two or three dredges having been at work. On the Quesnel a prospecting dredge was operated for a portion of the year with good results but made only a small output. Another dredge is reported to have been prospecting on the Thompson river, with what results has not been learned. At Lytton the old Cobeldick dredge has been working. Here Mr. Turner, the director who was sent out from England to investigate for the company the working of the dredge, made the discovery that, of the gold dredged up from the bottom less than 10 per cent was recovered on the tables, the remaining 90 per cent going off again with the tailings, although the gold-saving appliances on this machine were about the most complete of any in British Columbia. It certainly appears as though here is the point of failure in most of the dredging operations in British Columbia, and the realization of this fact should soon lead to the removal of the difficulty, when, only, will this industry become the success which the conditions seem to warrant.

"*Lode Gold Mining.*—Lode gold mining has this year made a production of $4,888,269, being an increase of $539,666 over the previous year, or about 12½ per cent. This increase is attributable to the greatly increased tonnage of the mines of Trail Creek and the Boundary. The increased tonnage has brought with it lower values per ton of ore mined, but this has been more than compensated for by the cheaper smelting, mining and transportation rates thus rendered possible. Gold is the only metal which may hope to escape the fluctuations of the market, and it is the gold contents of the ore that has enabled most of

PRECIOUS METALS.

Gold.

British Columbia.

our copper mines to continue production in the face of a 27 per cent drop in the price of the latter metal.

"The product of lode gold mining in British Columbia has shown the steadiest and most regular increase, and this product is the most valuable which the province has. It can, however, not be classed as a separate branch of the industry of mining, inasmuch as the gold is mostly found in combination with other metals, such as copper or silver. A certain amount of this production is derived from stamp milling, &c. but it is chiefly due to smelting."

" Approximately the gold has been derived as follows :—

Direct smelting of copper-gold ores	$ 4,232,948
Combined amalgamation and concentration	655,321
	$ 4,888,269 "

The following tables show the production of the Rossland mines and illustrate the average results attained during the past nine years.

NET PRODUCTION PER SMELTER RETURNS.

Year.	Ore, tons, 2,000 lbs.	Gold, oz.	Silver, oz.	Copper, lbs.	Value.
1894	1,856	3,723	5,357	106,229	$ 75,510
1895	19,693	31,497	46,702	840,420	702,459
1896	38,075	55,275	89,285	1,580,635	1,243,360
1897	68,804	97,024	110,068	1,819,586	2,097,280
1898	111,282	87,343	170,804	5,232,011	2,470,811
1899	172,665	102,976	185,818	5,693,889	3,229,086
1900	217,636	111,625	167,378	2,071,865	2,739,300
1901	283,360	132,333	970,460	8,333,446	4,621,299
1902	329,534	162,146	373,101	11,667,807	4,893,396
Total	1,242,905	783,942	2,118,973	37,345,888	22,072,500

PRECIOUS METALS.

Gold.

British Columbia.

AVERAGE NET SMELTER RETURNS OR ACTUAL YIELD PER TON.

Year.	Gold.	Silver.	Copper.	Value.
	Ounces.	Ounces.	Per cent.	$ cts.
1894..........	2·00	2·89	2·85	40.69
1895..........	1·60	2·41	2·10	35.67
1896..........	1·45	2·34	2·08	32.65
1897..........	1 42	1·60	1·32	30.48
1898..........	·78	1·54	2·35	22.10
1899..........	·596	1·07	1·65	18.70
1900..........	·513	769	·476	12.58
1901..........	·467	3·424	1·470	16.31
1902..........	·492	1·132	1·770	14.85
Average 1,242,905 tons....	·631	1·705	1·502	17.76

SILVER.

Silver.

Silver ores are mined in Canada in the provinces of Quebec, Ontario and British Columbia, and a certain quantity is also recovered from the placer gold found in the Yukon district. The total production in Canada in 1902 was 4,291,317 ounces, valued at $2,238,351, or a decrease from the output of 1901 of 1,247,875 ounces, or over 32 per cent.

Statistics of the production of silver since 1887 are shown in Table No. 12.

TABLE 12.

PRECIOUS METALS.

SILVER.—ANNUAL PRODUCTION.

Calendar Year.	Ontario.		Quebec.		British Columbia.		Total.	
	Ounces.	Value.	Ounces.	Value.	Ounces.	Value.	Ounces.	Value.
1887..	190,495	$186,304	146,898	$143,666	17,690	$17,301	355,083	$347,271
1888..	208,064	195,580	149,388	140,425	79,780	74,993	437,232	410,998
1889..	181,609	169,986	148,517	139,012	53,192	49,787	383,318	358,785
1890..	158,715	166,016	171,545	179,436	70,427	73,666	400,687	419,118
1891..	225,633	222,926	185,584	183,357	3,306	3,266	414,523	409,549
1892..	41,581	36,425	191,910	168,113	77,160	67,592	310,651	272,130
1893..	....	8,689	....	126,439	....	195,000	....	330,128
1894..	....	....	101,318	63,830	746,379	470,219	847,697	534,049
1895..	....	....	81,753	53,369	1,496,522	976,930	1,578,275	1,030,299
1896..	....	....	70,000	46,942	3,135,343	2,102,561	3,205,343	2,149,503
1897..	5,000	2,990	80,475	48,116	5,472,971	3,272,289	5,558,446	3,323,395
1898..	85,000	49,521	74,932	43,655	4,292,401	2,500,753	4,452,333	2,593,929

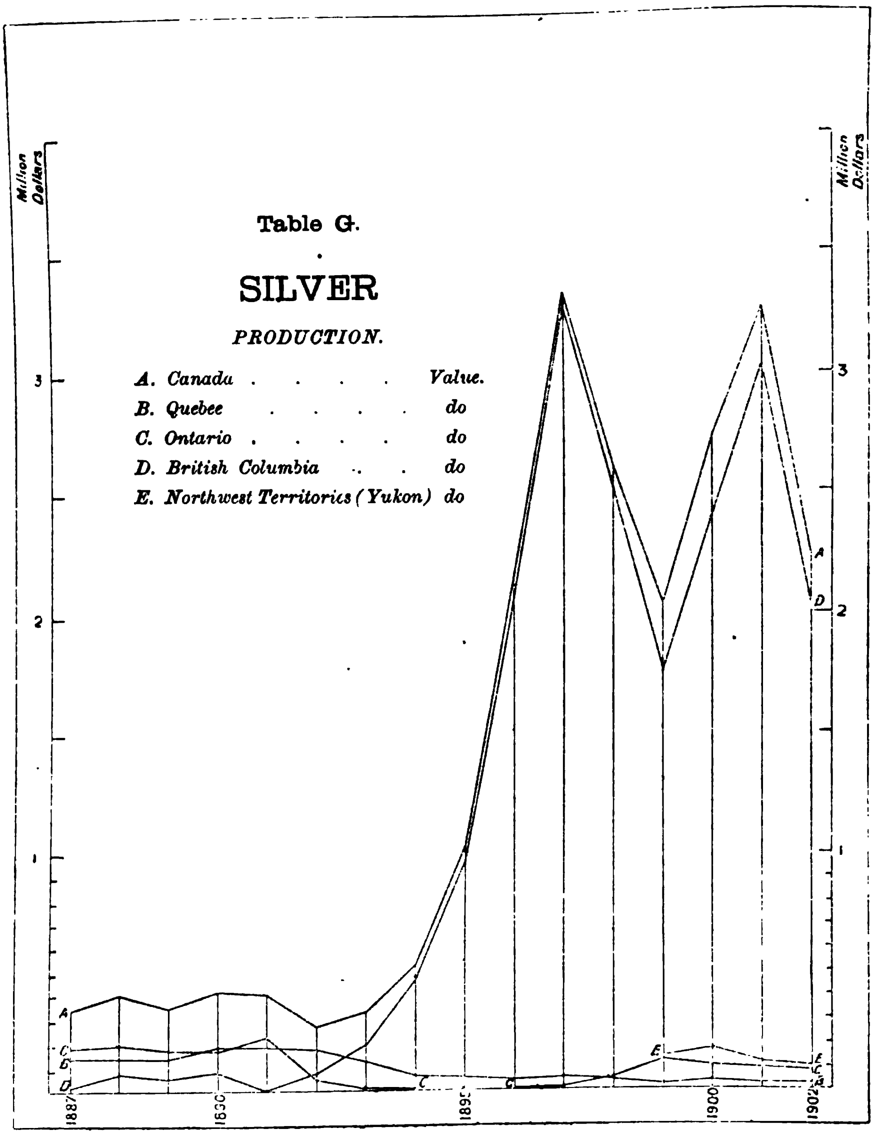


Table G.
SILVER
PRODUCTION.
A. Canada . . . . . Value.
B. Quebec . . . . . do
C. Ontario . . . . . do
D. British Columbia . . . do
E. Northwest Territories (Yukon) do
Million Dollars
Million Dollars
1887
1890
1895
1900
1902

PRECIOUS METALS.

Silver.

PROVINCE.	1899.		1900.		1901.	
	Ounces.	Value.	Ounces.	Value.	Ounces.	Value.
Quebec	40,231	$23,970	58,400	$35,817	41,459	$24,440
Ontario........	202,000	120,352	161,650	99,140	151,400	89,250
Yukon district.	230,000	137,034	290,000	177,857	195,000	114,953
British Col'mbia	2,939,413	1,751,302	3,958,175	2,427,548	5,151,333	3,036,711
	3,411,644	2,032,658	4,468,225	2,740,362	5,539,192	3,265,354

PROVINCE.	1902.	
	Ounces.	Value.
Quebec..	42,500	$ 22.168
Ontario..	145,000	75,632
Yukon district..................................	185,900	96,965
British Columbia..............................	3,917,917	2,043,586
	4,291,317	2,238,351

The greater part of the silver production since 1894 has been obtained from British Columbia, the proportion in 1902 being over 91 per cent.

The output from the province of Quebec is represented by the small amount contained in the pyrites ores mined in the vicinity of Capelton in the Eastern Townships.

In Ontario the West End Silver Mountain Mine, situated south-west of Port Arthur in the Thunder Bay district, is at present the chief producer.

The production by district in British Columbia is shown in the following table :—

PRECIOUS METALS.

Silver.

British Columbia.

TABLE 13.

PRECIOUS METALS.

SILVER:—BRITISH COLUMBIA.—PRODUCTION BY DISTRICTS.

District.	1899.	1900.	1901.	1902.
	Ounces.	Ounces.	Ounces.	Ounces.
Cariboo	....	....	....	4
Cassiar	....	....	82	224
Kootenay East—				
Fort Steele division	33,516	960,411	718,451	114,506
Other divisions	1,627	2,219	34,181	27,918
Kootenay West—				
Ainsworth division	268,165	352,167	324,913	320,719
Nelson "	483,659	109,870	377,167	273,870
Slocan "	1,891,025	2,121,176	2,276,259	2,223,810
Trail Creek "	185,818	167,378	970,460	373,101
Other divisions	48,463	96,416	133,774	241,584
Yale				
Osoyoos division	2,719	112,145	241,489	219,798
Similkameen	16	....	....	....
Yale	47	....	74	542
Coast and other districts	24,358	36,393	74,483	121,841
Totals	2,939,413	3,958,175	5,151,333	3,917,917

Comparing the output for 1902 with the previous year, it will be seen that nearly every division with the exception of the coast district has shown a falling off, the most notable decreases being in the Fort Steele division of East Kootenay and in the Nelson and Trail Creek divisions of West Kootenay.

The following tables show the output and average yield per ton of the Slocan mines for the past eight years.

NET PRODUCTION PER SMELTER RETURNS.

Year.	Ore, Tons, 2,000 lbs.	Silver oz.	Lead, lbs.	Gold. oz.	Values.
1895	9,514	1,122,770	9,666,324	6	$1,045,600
1896	16,560	1,954,258	18,175,074	152	1,854,011
1897	33,567	3,641,287	30,707,705	193	3,280,686
1898	30,691	3,068,648	27,063,595	60	2,619,852
1899	21,507	1,891,025	16,660,910	14	•1,740,372
1900	25,520	2,121,176	19,365,743	5	2,063,908
1901	25,493	2,276,259	15,025,759	244	1,865,752
1902	21,153	2,223,810	13,651,144	353	1,608,827
Total	184,005	18,299,233	150,316,254	1,027	16,079,008

PRECIOUS METALS.

Silver.

British Columbia.

AVERAGE YIELD PER TON.

Year.	Silver.	Lead.	Values.
1895	118·0 oz.	50·8%	$109.90
1896	118·0 "	54·9%	111.95
1897	108·5 "	45·7%	97.73
1898	100·0 "	44·1%	85.36
1899	87·9 "	38·7%	80.92
1900	83·1 "	37 9%	80.87
1901	89·3 "	29·5%	73.19
1902	105·1 "	32·3%	76.06
Average for eight years, 184,005 tons	99·4 oz.	40·8%	$ 87.38

The value of silver ores exported is given in Table 14, as follows:—

TABLE 14.

PRECIOUS METALS.

SILVER.—EXPORTS OF ORE.

Calendar Year.	Value.	Calendar Year.	Value.
1886	$ 25,957	1895	$ 994,354
1887	206,284	1896	2,271,959
1888	219,008	1897	3,576,391
1889	212,163	1898	2,902,277
1890	204,142	1899	1,623,905
1891	225,312	1900	2,341,872
1892	56,688	1901	2,026,727
1893	213,695	1902	1,820,058
1894	359,731		

PYRITES.

PYRITES.

The production of pyrites in 1902 reached a total of 35,616 tons valued at $138,939. The greater part of this output represents the product of the mines of the Eustis Mining Company and the Nichols Chemical Company at Eustis and Sherbrooke in the Eastern Townships, province of Quebec. A small quantity of iron pyrites is mined at the Jarman mine in the township of Madoc, Hastings county, Ontario, and is included in the above total.

Pyrites.

Production.

TABLE 1.

PYRITES.

ANNUAL PRODUCTION.

Calendar Year.	Tons. 2,000 lbs.	Value.
		$
1886	42,906	193,077
1887	38,043	171,194
1888	63,479	285,656
1889	72,225	307,292
1890	49,227	123,067
1891	67,731	203,193
1892	59,770	179,310
1893	58,542	175,626
1894	40,527	121,581
1895	34,198	102,594
1896	33,715	101,155
1897	38,910	116,730
1898	32,218	128,872
1899	27,687	110,748
1900	40,031	155,164
1901	35,261	130,544
1902	35,616	138,939

Imports.

TABLE 2.

PYRITES.

IMPORTS :—BRIMSTONE AND CRUDE SULPHUR.

Fiscal Year.	Pounds.	Value.
		$
1880	1,775,489	27,401
1881	2,118,720	33,956
1882	2,375,821	40,329
1883	2,336,085	36,737
1884	2,195,735	37,463
1885	2,248,986	35,043
1886	2,922,043	43,651
1887	3,103,644	38,750
1888	2,048,812	25,318
1889	2,427,510	34,006
1890	4,440,799	44,276
1891	3,601,748	46,351
1892	4,769,759	67,095
1893	6,381,203	77,216
1894	5,845,463	61,558
1895	4,900,225	56,965
1896	6,934,190	63,973
1897	8,672,751	87,719
1898	38,026,798	373,786
1899	24,517,026	265,799
1900	21,128,656	215,433
1901	23,856,651	270,608
1902*	24,640,735	325,307

*Brimstone, crude, or in roll or flour, and sulphur in roll or flour. Duty free.

SALT.

SALT.

Production.

The production of salt in Ontario in 1902 from the deposits in the counties of Essex, Lambton, Middlesex, Huron and Bruce, reached a total, according to returns from operators, of 64,456 tons, valued at $292,581, exclusive of packages. The total value of packages used was $109,757.

Although the production for the year under consideration has been the largest recorded, the variation from year to year has been comparatively small, as a glance at Table 1 will show.

The output of salt in 1886 was 62,359 tons and in only five years between that year and the present time has the output been less than 50,000 tons.

Ontario is the only province at present producing salt. In 1896 a few tons were manufactured at the south end of Lake Winnipegosis, Manitoba, but the industry has not been followed up in this district. Small quantities of brine have occasionally been evaporated at Plumweseep, N.B., and sold locally along the line of the Intercolonial Railway, but these operations have apparently ceased since 1898.

The exports af salt, which are of small amount, are shown in Table No. 2. Tables Nos. 3 and 4 show the quantities and values of the salt imported. The value of the salt imported, on which a customs duty is levied, has ranged from $20,000 to $80,000 a year, the value in 1902 being $39,605. Salt imported from the United Kingdom or any British possession, or imported for the use of the sea or gulf fisheries, is free of duty, and a large proportion of the trade of eastern Canada is supplied with salt imported under this class. The quantity imported duty free in 1902 was 119,324 tons, valued at $385,629.

SALT.

Production.

TABLE 1.

SALT.

ANNUAL PRODUCTION.

Calendar Year.	Tons.	Value.
1886	62,359	$227,195
1887	60,173	166,394
1888	59,070	185,460
1889	32,832	129,547
1890	43,754	198,857
1891	45,021	161,179
1892	45,486	162,041
1893	62,324	195,926
1894	57,199	170,687
1895	52,376	160,455
1896	43,960	169,693
1897	51,348	225,730
1898	57,142	248,639
1899	59,339	254,390
1900	62,055	279,458
1901	59,428	262,328
1902	64,456	292,581

Exports.

TABLE 2.

SALT.

EXPORTS.

Calendar Year.	Bushels.	Value.
1880	467,641	$46,211
1881	343,208	44,627
1882	181,758	18,350
1883	199,733	19,492
1884	167,029	15,291
1885	246,794	18,756
1886	224,943	16,886
1887	154,045	11,526
1888	15,251	3,987
1889	8,557	2,390
1890	6,605	1,667
1891	5,290	1,277
1892	2,000	504
1893	4,940	1,267
1894	4,639	1,120
1895	4,865	959
1896	3,842	899
1897	5,383	1,193
1898	5,202	1,252
1899	11,205	2,773
1900	37,653	8,997
1901	39,224	6,510
1902	9,331	3,798

TABLE 3.

SALT.

IMPORTS:—SALT PAYING DUTY.

Salt. Imports.

Fiscal Year.	Pounds.	Value.	Fiscal Year.	Pounds.	Value.
1880	726,640	$ 3,916	1891	15,140,827	$59,311
1881	2,588,465	6,355	1892	18,648,191	65,963
1882	3,679,415	12,318	1893	21,377,339	79,838
1883	12,136,968	36,223	1894	15,867,825	53,336
1884	12,770,950	38,949	1895	8,498,404	29,881
1885	10,397,761	31,726	1896	7,665,257	24,550
1886	12,266,021	39,181	1897	11,911,766	33,470
1887	10,413,258	35,670	1898	11,068,785	32,792
1888	10,509,799	32,136	1899	11,781,453	32,839
1889	11,190,088	38,968	1900	11,028,337	30,180
1890	15,135,109	57,549	1901	11,625,688	34,087

		Duty.	Pounds.	Value.
1902	Salt, coarse, N.E.S	5c. per 100 lbs.	10,786,285	$25,427
	Salt, fine, in bulk	5c. "	644,372	1,014
	Salt, N.E.S., in bags, barrels or other packages	7½c. "	2,462,192	13,164
	Total		13,892,849	39,605

TABLE 4.

SALT.

IMPORTS—SALT NOT PAYING DUTY.

Fiscal Year.	Pounds.	Value.	Fiscal Year.	Pounds.	Value.
1880	212,714,747	$400,167	1892	201,831,217	314,995
1881	231,640,610	488,278	1893	191,595,530	281,462
1882	166,183,962	311,489	1894	196,668,730	328,300
1883	246,747,113	386,144	1895	201,691,248	332,711
1884	225,390,121	321,243	1896	205,005,100	338,888
1885	171,571,209	255,719	1897	215,844,484	312,117
1886	180,205,949	255,359	1898	202,634,927	293,410
1887	203,042,332	285,455	1899	183,046,365	267,520
1888	184,166,986	220,975	1900	193,554,550	295,253
1889	180,847,800	253,009	1901	216,271,603	339,887
1890	158,490,075	252,291	1902*	238,648,737	385,629
1891	195,491,410	321,239			

* Salt imported from the United Kingdom, or any British possession, or imported for the use of the sea or gulf fisheries.

Following is a list of the chief producers of salt in Ontario :— Producers.

The Canadian Salt Company, Ltd., E. G. Henderson, vice-Pres., Windsor, Ont.
Saginaw Lumber and Salt Co .... Sandwich, Ont.
Mooretown Salt Co., Ltd .... Mooretown, Ont.
Carter & Kittermaster .... " "
Sarnia Salt Co., Ltd .... Sarnia "

SALT.

Producers.

Sarnia Bay Mills Co	Sarnia	Ont
Cleveland Lumber & Salt Co	"	"
Elarton Salt Works Co., Ltd., C. V. Morris	Warwick	"
Parkhill Salt Co., A. K. Hodgins	Parkhill	"
Exeter Salt Works Co., J. B. Carling, Secy	Exeter	"
Hensall Salt Works, Geo. McEwan	Hensall	"
I. F. Coleman	Seaforth	"
Lake Huron and Manitoba Milling Co., Ltd., P. A. McGaw, Secretary	Goderich	"
R. & J. Ransford	Clinton,	"
Operating the following plants—		
Courtright Salt Works	Courtright	Ont.
Stapleton Salt Works	Clinton	"
North American Chemical Co	Goderich	"
Goderich Salt Works	"	"
Brussels Salt Works	Brussels	"
Clinton Salt Works, John McGarva	Clinton	"
Maitland Salt Works, John S. Platt	Goderich	"
The Grey, Young & Sparling Co., of Ont., Ltd., F. G. Sparling,	Wingham	"
The Ontario People's Salt & Soda Co., Ltd., Jno. Tolmie, Sec.,	Kincardine	"
— Ryghtmeyer	"	"

Deposits.

THE SALT DEPOSITS OF CANADA.

The following extended article has been prepared by Mr. Denis as a result of his observations in the Ontario Salt field supplemented by reference to the available literature of the subject:—

Although a small amount of salt has been produced in Canada from natural brine springs in New Brunswick and Manitoba, these enterprises form quite a minor feature of the industry. In these cases, the salinity of the spring seems to be due to the leaching out by percolating surface waters, of salt scattered through the formation as small aggregations and isolated crystals. The presence of such springs must not therefore be taken to necessarily indicate the presence of extensive salt deposits.

The country's chief resource in this respect consists of the salt beds underlying large areas in Ontario, adjacent to the eastern shores of Lake Huron. The territory, so far proved, has an area of approximately 2,500 square miles fronting on the shore of the lake between Kincardine and Lake Erie, and reaching inland at its greatest breadth to a distance of about 40 miles.

The beds of rock-salt owe their origin to a process of sedimentation and deposition produced by the surface evaporation of bodies of saline water; such process being comparable to that which produces in warm climates salt by solar evaporation from sea water or other brines.

SALT.
Deposits.

This is at present going on for instance in the Dead Sea, in the Great Salt lake of Utah and many other bodies of water without outlets, where the quantity of water annually discharged into them, by streams holding salts in solution, is less than the surface evaporation. A similar result happens in the case of basins and bays on the sea coast cut off from the main body of the ocean by sand-bars, etc. Such concentrations of salt waters and eventual depositions from the saturated brines are known to have taken place in most of the geological periods from the Silurian up to the present time, giving rise to the beds of rock-salt which are found in formations of various ages.

From the very nature of the mode of deposition of beds of rock-salt, it can easily be understood that they cannot be expected to be pure sodium chloride. Even the purest ones always contain other salts which may be classified as impurities, such as sulphates and chlorides of calcium, potassium and magnesium.

In some parts of the world the salt deposits occur under such favourable conditions and are so pure that the rock-salt is mined and removed in the solid state. No operations of this kind are, however, carried on in Canada. Where the salt is mixed with layers of rock, gypsum, etc., or is buried at great depths, another mode of extraction is resorted to. Wells or bore-holes are sunk to the salt beds, fresh water is let down and after dissolving the salt, is pumped up in the form of brine; or in certain cases the water infiltrating through the rocks is in sufficient quantity to be taken advantage of as solvent. Both methods are followed in the Ontario field.

Pure water at ordinary temperature dissolves somewhat more than one third its weight of salt, or from thirty five to thirty six hundredths. As results of experiments it appears that 100 parts by weight of pure saturated brine at temperatures of from 32° to 70° Fahrenheit contain from 26·3 to 26·7 parts of salt, the specific gravity of the brine being 1.205 at 60° Fahrenheit. The salometer or instrument used to fix the value of the brines is an aerometer with an arbitrary scale on which 0° represents the density of pure water and 100° the density of saturated brine, both at a temperature of 60° F. The following table gives, in the first column, the degree of the salometer; in the second the degree of Baumé aerometer, which is a hydrometer with an arbitrary scale; the third column the true specific gravity; the fourth, the parts of salt in 100 of the brine; the fifth, the number of gallons of brine required for one bushel of salt. As may be seen these two last columns are based on the supposition that a saturated brine contains 26·5% of salt, which is the quantity arrived at through the further experiments on salt solutions.

SALT DEPOSITS.

Earlier experiments gave as results 25·7% and formerly tables were calculated on that basis. From a practical standpoint, however, it is a question whether the earlier tables are not more accurate if the slight amount of impurities present in the brine is taken into account.—

Salometer degrees.	Baumé degrees.	Specific gravity.	Per cent of salt.	Gallons of Brine for a bushel of salt.
2	.52	1.003	.530	1,264.5
4	1.04	1.007	1.060	629.7
6	1.56	1.010	1.590	418.6
8	2.08	1.014	2.120	312.7
10	2.60	1.017	2.650	249.4
12	3.12	1.021	3.180	207.0
14	3.64	1.025	3.710	176.7
16	4.16	1.028	4.240	154.2
18	4.68	1.032	4.770	136.5
20	5.20	1.035	5.300	122.5
22	5.72	1.039	5.830	111.0
24	6.24	1.043	6.360	101.3
26	6.76	1.046	6.890	93.3
28	7.28	1.050	7.420	86.3
30	7.80	1.054	7.950	80.2
32	8.32	1.058	8.480	74.9
34	8.84	1.061	9.010	70.3
36	9.36	1.065	9 540	66 2
38	9.88	1.069	10.070	62.4
40	10.40	1.073	10.600	59.1
42	10.92	1.077	11.130	56.1
44	11.44	1.081	11.660	53.3
46	11.96	1.085	12.190	50.8
48	12.48	1.089	12.720	48.5
50	13.00	1.093	13.250	46.4
52	13.52	1.097	13.780	44.5
54	14.04	1.102	14 310	42.6
56	14.56	1.106	14.840	41.0
58	15.08	1.110	15.370	39.4
60	15.60	1.114	15 900	37.9
62	16.12	1.118	16.430	36.6
64	16.64	1.123	16.960	35.3
66	17.16	1.127	17.490	34.1
68	17.68	1.131	18.020	33.0
70	18.20	1.136	18.550	31.9
72	18.72	1.140	19.080	30.9
74	19.24	1.144	19.610	30.0
76	19.76	1.149	20.140	29.0
78	20.28	1.154	20.670	28.2
80	20.80	1.158	21.200	27.4
82	21.32	1.163	21.730	26.6
84	21.84	1.167	22.260	25.9
86	22.36	1.172	22.790	25.2
88	22 88	1.177	23.320	24.5
90	23.40	1.182	23.850	23.8
92	23.92	1.186	24.380	23.2
94	24.44	1.191	24.910	22.7
96	24.96	1.196	25.440	22.1
98	25.48	1.201	25.970	21.6
100	26.00	1.205	26.500	21.4

NOTE.—The above is taken from the table by Dr. Englehardt, published in the New York State Museum Bulletin No. 11 on Salt and Gypsum industries of New York.

SALT. Deposits.

As may be observed by a comparison of the above tables of production, the quantity of salt imported into Canada at present, roughly speaking is double the amount produced in the country. This is not owing to a lack of sources from which the whole of the consumption could be derived, but is due to the fact that salt is produced more cheaply in England, from which country the greater proportion of the imports come. This is probably because the extensive salt deposits of Cheshire are in close proximity to the coal supply used for the evaporation of the brine, and also on account of the cheapeness of labour. As a measure of protection and help to the Canadian fishery industry, the salt imported for its use is admitted free of duty, and as very low freight rates across the Atlantic can be obtained, salt being carried as return freight and ballast, the whole Atlantic sea board trade is monopolized by English salt.

In a paper on the 'Goderich Salt Region,' published in Vol. V. of the American Institute of Mining Engineers, Dr. T. Sterry Hunt draws a comparison between the Goderich salt and the rock-salt of Cheshire, England, the most productive field of Great Britain. The sample of Canadian salt was broken off the core of the diamond drill hole put down by Mr. Attrill. Pieces of equal size were taken from each linear foot of the white translucent portion, measuring ten feet, of the second bed of salt which has a total thickness of 25 feet 4 inches.

The analysis of English salt made by Dr. Grace Calvert for Messrs. Fletcher & Rigby, is taken from a report to the British House of Commons, in 1873, and is of 'Crushed Marston rock-salt.'

The two analyses are respectively as follows :—

	Goderich.	Cheshire.
Chloride of sodium	99·687	96·70
„ calcium	·032	·68
„ magnesium	·095	trace.
„ potassium		„
Sulphate of lime	·090	·25
Insoluble in water	·017	1·74
Moisture	·079	·63

Deducting the moisture in both cases, the amounts of impurities in the two salts are, Goderich, 0·234 per cent, Cheshire, 2·67 per cent; that is, the English salt contains eleven times more impurities than the Canadian salt.

In the following brief description of the sources of salt in Canada, the deposits are taken up in their geographical order, from east to west, irrespective of their importance from a commercial standpoint.

SALT.
Deposits.

In the provinces of Nova Scotia and New Brunswick, no deposits of rock salt have been discovered, but numerous salt springs are known, to exist whose brines could be evaporated for salt. These springs are as a rule found in the neighbourhood of the gypsum deposits. Some have been noticed at Pomquets, South river, Brierly brook, Addington Forks, Spring Hill, and other places. They generally take their source in the measures of Lower Carboniferous age.

The manufacture of salt from these brines has been attempted at several places, but in no case does it seem to have been very successful. One of the first attempts was made at Salt Springs, on the West river of Pictou, in 1813. The presence of brine oozing out at the surface was taken as evidence of the presence of a rock-salt bed within easy access, and in the hope of reaching it a shaft was sunk about 200 feet without any results. Some years later the brine itself was used in the manufacture of salt.

Some thirty years ago at Antigonish village, the Nova Scotia Salt Works and Exploration Company put down a bore-hole where the railway station now stands. At a depth of about 159 feet, after penetrating eighteen feet of gypsum, a flow of pure strong brine was started. A plant was erected for the production of salt, and a considerable quantity was manufactured, but the brine eventually became weaker, the original strength having been about 35° of the salinometer. Another bore-hole was sunk, but without satisfactory results, and the enterprise was abandoned.

At Black Brook, Cumberland county, the brine of a spring was used for some time in the manufacture of salt for house use.

At Spring Hill a brine was found recording 30° to 35° of the salinometer; this was also the object of an attempt to manufacture salt.

In New Brunswick, salt springs are known to exist in the vicinity of Sussex and at Saltspring Brook, both in King's county, and on the Tobique river in Victoria county. These springs have their sources in the Lower Carboniferous rocks.

Of those known springs, the Sussex ones are the most important and they are worked intermittently, the product being used locally. These springs were first operated about 100 years ago. There are half a dozen springs within a radius of a quarter of a mile. The brine records 20°. In all cases work is conducted in open pans and wood is used for fuel.

SALT.
Deposits.

At Salina, King's county, a brine collected from a bore hole 350 feet deep, gave the following results.

	Grains per imp. gallon.
Potassium chloride	19·963
Sodium "	1293·648
Magnesium "	22·315
Sulphate of lime	268·212
" magnesia	11·336
	1615·474

The analysis was made in the laboratory of the Geological Survey of Canada.

In the province of Quebec, although there is an abundance of mineral springs, none of the known ones are suited to the manufacture of common salt. Those in which the proportion of sodium chloride might be sufficient, contain too much earthy chlorides.

The province of Ontario is responsible for almost the total Canadian production of salt, the exceptions being insignificant quantities manufactured intermittently from natural springs for local use only.

The deposits from which this salt is obtained, are found in a basin along the eastern shore of Lake Huron, river and lake St. Clair and Detroit river, and form part of the Onondaga formation of Silurian age. The name of the formation is derived from the county of Onondaga in the state of New York, where these rocks were first studied. In this state this formation had for a long time been known to be saliferous, through the presence of saline springs. In fact, in the "Relations of the Jesuits" as far back as 1646, mention is made of an occurrence of salt springs in the Canton of Onondaga, and the first record of salt manufactured in that region, dates back to 1788, from salt springs, the source of which is the Onondaga formation. It was not until 1865 that this formation was discovered to be saliferous in Canada. The discovery was made accidentally, near the town of Goderich, in a bore hole which was being sunk in search of oil, and which at a depth of 964 feet, struck rock-salt. The boring was continued to 1,010 feet and in that distance passed through 30 feet of rock-salt.

For several years the salt deposits were supposed to be confined to the counties of Bruce and Huron, but they have of late years been recognized to extend south as far as Essex county; the most important salt works in Ontario being now located at Windsor. In the geological column the Onondaga, also called Salina group, is seen

SALT. Deposits.

to be overlaid by the Corniferous and underlaid by the Guelph formation. Its outcrop crosses into Canada from the state of New York at the Niagara river, whence it has a north-west direction to Lake Huron. It dips to the south-west at a very slight angle, so that by boring it is easily reached all along the west shore of the Ontario peninsula, and on the opposite shore in Michigan. The Onondaga includes, both in Canada and New York, beds of gypsum which are worked along the outcrop.

Prof. James Hall in his "Geology of the 4th District" gives the following description of the Salina or Onondaga formation:—"Succeeding the Niagara group is an immense development of shales and marls with shaly limestones including veins and beds of gypsum. The general colour is ashy, approaching drab with some portions of dark bluish green. The lower part is of deep red with spots of green. Succeeding this, where protected from atmospheric influences, the rock is blue like ordinary blue clays, with bands of red or brown. This portion and that succeeding it are often green and spotted, and contain seams of fibrous gypsum, and small masses of reddish selenite and compact gypsum. From this it becomes gradually more gray with a thin stratum of clayey limestone, which is sometimes dark, though generally of the same colour as the surrounding mass. The formation terminates upward with a gray or drab limestone called by Vanuxem the 'magnesian deposit.'" This succession was of course gathered from the outcrops of the formation, hence no rock salt was found in it; on account of its solubility the mineral cannot remain at the surface. It was known, however, even before the actual discovery of rock salt that this formation was the source of the salt springs of the counties of Onondaga and Cayuga, as mentioned by Vanuxem in his "Geology of the third district of New York", but it was only in 1878, that, is more than twelve years after the discovery of the Goderich salt deposits, that rock—salt was struck in the state of New York, in the county of Wyoming. As in the case of the Canadian deposit it was found accidentally in the course of a boring for oil.

As mentioned above, the outcrop of the Onondaga in the State of New York runs parallel to the shore of Lake Ontario, and enters Canada at the Niagara river. Its thickness here is estimated at between 200 and 300 feet. In the Geology of Canada 1863, the folowing short description of the rocks at the outcrop is given:—"The exposures of the Onondaga formation in Canada, so far examined, appear to belong chiefly to the upper portions, from the summit to a little below the gypsum-bearing beds. Those portions consist of

SALT. Deposits.

dolomites and soft crumbling shales, which are greenish and sometimes dark brown or bluish in colour, and are often dolomitic. The dolomites are mostly of a yellowish brown or drab colour and are in beds which seldom exceed a foot in thickness. They often exhibit the vesicular or lenticular cavities just described. Some beds of a bluish dolomite are also met with; and many of the strata both above and below the gypsum, contain such a proportion of clay as make them fit for hydraulic cement.

"The beds of gypsum are never continuous for long distances but appear as detached lenticular or dome-like masses; the strata above them being arched over and often broken, while those below constitute an even undisturbed floor. The gypsum is inter-stratified with the dolomite and often separated by beds of it. The layers of gypsum may sometimes extend for a quarter of a mile, but they have always been found, on working, to be lenticular in form, and to gradually thin out, until the strata above and below the masses, come in contact. This peculiar structure gives rise to mounds on the surface; which are regarded by the inhabitants, as indicative of the presence of gypsum beneath."

As shown on the map accompanying the Geology of Canada 1863, the outcrop of the lowest beds of these rocks after entering Canada at a point near Chippawa village, follows along a line parallel to the lake shore to a point some two miles north of Brantford. From here, it follows a direction north north-west as far as the southern part of the township of Amabel, where it takes a sharp turn and goes under the waters of Lake Huron. At almost any place in that part of the province of Ontario west of this boundary, the measures of the Onondaga can be reached by bore holes of various depths after penetrating through the overlying formations. But of this development, only a limited part is salt-bearing. For a long time after the discovery of the salt beds, the saliferous deposits were thought to be limited to the counties of Huron and Bruce, and it was only in 1884 that it was discovered that the salt basin extended south to Courtright, and some eight years later, salt was struck at Windsor in Essex county.

The limits of the saliferous area as it now stands proved are given further on.

It was in 1865 that the salt beds were first struck in the course of a boring for oil at Goderich Huron county and during several years following this first discovery a certain number of wells were sunk in various places around the town, but the most important to throw light on the stratigraphical sequence of the region, was the diamond drill

SALT. Deposits.

hole put down by Mr. Henry Attrill in 1876, with the view of determining the nature and extent of the salt-beds. The results of the drilling as interpreted from the log and the cores by Dr. T. Sterry Hunt, have been summarized by him as follows :—

	Thickness.		Total depth.	
	Ft.	in	Ft.	in
Clay, gravel and boulders	78	9	78	9
Dolomite, with thin limestone layers	278	3	357	0
Limestone, with corals, chert and beds of dolomite	276	0	633	0
Dolomite with seams of gypsum	243	0	876	0
Variegated marls, with beds of dolomite	121	0	997	0
Rock-salt 1st bed	30	11	1027	11
Dolomite, with marls towards the base	32	1	1060	0
Rock-salt 2nd bed	25	4	1085	4
Dolomite	6	10	1092	2
Rock-salt 3rd bed	34	10	1127	0
Marls with dolomite and anhydrite	80	7	1207	7
Rock-salt 4th bed	15	5	1223	0
Dolomite and anhydrite	7	0	1230	0
Rock-salt 5th bed	13	6	1243	6
Marls, soft with anhydrite	135	6	1379	0
Rock-salt 6th bed	6	0	1385	0
Marls, soft, with dolomite and anhydrite	132	0	1517	0

The drilling thus showed a total thickness of salt of 123 feet in a distance of 388 feet divided up into six beds, ranging from six feet to nearly thirty-five in thickness. Of these the first bed has intercalated with it layers of dolomite, and is stained by earthy matter. This bed would not be pure enough for mining.

The second and third beds which are separated by a layer of less than seven feet are very pure. They measure together over sixty feet, and represent practically one great mass of rock-salt.

The fourth bed, mesuring from 1207 to 1223 feet is uneven in purity, only the upper two feet and the lower two feet nine inches of the core were saved. The former was somewhat impure, the lower was white salt with layers of dolomite.

The fifth bed measures thirteen and a half feet, and from what can be judged from what was obtained of the core (five and a half feet)the salt is impure though white in portions.

The sixth bed is pure white and translucent and measures six feet.

The limits of the salt basin cannot be shown on the map by a definite sharp boundary, but as far as it now stands proved the land-salt area of Ontario is approximately contained within lines joining the towns of Kincardine, Wingham, Brussels, London, Glencoe, Petrolia and a

point a few miles south of Sandwich in Essex county; on the west it SALT.
is of course bounded by the shores of Lake Huron, St. Clair river and Deposits.
Detroit river.

It is, moreover, very probable that the greater part of the western peninsula, comprising the counties of Kent and Essex is underlain by saltiferous horizons. A bore hole for oil, sunk in the township of Orford, Kent county, is said to have passed through a salt bed of 171 feet in thickness at a depth of 1,510 feet. This assertion would also be confirmed by the fact that in almost all the holes put down in that region great quantities of salt water are struck. The land part of the basin would therefore roughly speaking measure an extreme length of some 150 miles, from Kincardine to Lake Erie with a maximum width of about 40 miles at the centêr and tapering towards the ends. This would approximately cover an area of over 2,500 square miles.

The salt-beds are supposed to underlie St. Clair lake and river as well as the southern part of Lake Huron as rock-salt is struck in the state of Michigan on the opposite shores, in the same measure. Throughout this region the salt-beds are said to be practically continuous, although there are areas of greater or less extent in which salt-beds are absent, this is probably owing to inequalities in the sea or lake bottom which emerged above the waters of the Onondaga period, forming islands, over the surface of which, no salt was being deposited during this period. It would be very difficult to correlate the beds of salt at the different points where they have been struck, without more complete data. A number of logs of wells drilled in different parts of the basin are given below, and also a list of the depths at which salt was struck together with the thickness of rock-salt beds passed through. These with the log of the well, given on page 222 wil! give an idea of the conditions encountered by the driller in the region.

Logs.

Huron county, Goderich, Attrills bore hole :—
(See page 222.)

Huron county, Brussels :—

Surface	16	feet.
Limestone	100	"
Limestone, magnesian	266	"
Limestone with chert	180	"
Soapstone	353	"
Dolomite, grey	97	"
Dolomite	168	"
Sandstone, dark brown	64	"
	1,244	feet.

(J. Gibson, American Journal of Science, Vol. V, 3rd series.)

SALT.

Deposits.

No salt beds of importance were struck in this well, but the record is nevertheless very interesting, inasmuch that at a distance of less than one mile in a direction south-west from it, another well being sunk, struck thick beds of salt. This last well has been a steady producer since then. The north-eastern limit of the salt basin lies, therefore, probably between these two points.

Middlesex county, London Asylum well :—

Surface	130	feet.	
Limestone, hard	200	"	Corniferous.
" soft	270	"	
" hard	100	"	Onondaga with Guelph and Niagara, if present.
"	600	"	
Salt and shale	100	"	
Black shale	200	"	Clinton.
Red "	500	"	Medina.
Limestone and shale	150	"	Hudson river.

(G.S.C. Vol. V., Part Q. H. P. Brumell, Natural Gas and Petroleum.)

Lambton county, Petrolea :—

Surface	104	feet.	
Limestone	40	"	
Shale	130	"	
Limestone	15	"	Hamilton.
Shale	43	"	
Limestone	68	"	
" soft	40	"	
" grey	25	"	Corniferous.
" "	135	"	
" hard, white	500	"	With hard streaks of sand stone from two to five feet in thickness.
Gypsum	80	"	Onondaga.
Salt and shale	105	"	(Including the oriskany, if present.
Gypsum	80	"	
Salt and shale	140	"	
	1,505 feet		

Elevation above tide, 667 feet.

(G.S.C. Vol. V., Part Q. H. P. Brumell, Natural Gas and Petroleum.)

SALT.

Deposits.

Essex county, Windsor, Canadian Salt Works, Well No. 1 :—

Surface	132 feet.
Dolomite	118 "
Limestone (petroliferous)	25 "
Dolomite (marly)	85 "
Limestone (dark petroliferous)	30 "
Dolomite (crystalline)	20 "
Limestone, drab colour	75 "
Sandstone, pure quartzose	55 "
Dolomite, with some gypsum	50 "
" shaly	30 "
" grey and fawn	170 "
" with scales of carbonaceous matter	40 "
" grey	190 "
" shaly, argillaceous	57 "
Rock-salt	40 "
	1,167 feet.

Essex county, Windsor, Canadian Salt Works, Well No. 4 :—

Drift	133 feet.
Limestone	922 "
Salt	30 "
Limestone	25 "
Break in record	35 "
Salt	75 "
Limestone	100 "
Salt	70 "
Limestone	30 "
Salt	252 "
Limestone (ended in)	
	1,672 feet.

(Ont. Bureau of Mines, Sixth Report, p. 33.)

SALT.
Deposits.

In the following table is given a list of depths at which salt was encountered at different points in the province, together with the thickness of the salt beds :—

Locality.	Salt struck at depth of.		Thickness of Salt.		
	Feet.	In.	Feet.	In.	
Bruce county, Kincardine :—					
Total depth, 1,007 feet	993		14		
Huron county, Goderich, Attrill's diamond drill :-					
Total depth, 1,517 feet	997		30	11	
	1,060		25	4	
	1,092		34	10	
	1,027	7	15	5	
	1,230		13	6	
	1,379		6		
Huron county, Goderich, International well :—					
Total depth, 1,170 feet	1,054		19		
	1,103		21		
	1,130		32		
Huron county, Wingham :—					
Total depth, 1,185 feet	1,090		30		
Huron county, Brussels :—					
Total depth, 1,244 feet	No salt.				
Huron county, Brussels, ¾ miles south-west of above well :—					
Total depth, 1,000 feet	970				
Huron county, Blyth :—					
Total depth, 1,215 feet	1,125		90		
Huron county, Clinton :—					
Total depth, 1,239 feet	1,151		15		
	1,214		25		
Huron county, Seaforth :—					
Total depth, 1,135 feet	1,035		110		
Huron county, Hensall :—					
Total depth, 1,206 feet	1,090		116		with shale.
Huron county, Exeter :—					
Total depth, 1,251 feet	1,135				
Middlesex county, London, Asylum well :—					
Total depth, 2,250 feet	1,400		100		with shale.
Middlesex county, Glencoe :—					
Total depth, 1,510 feet	1,290		104		with shale.
Lambton county, Port Franks :—					
Total depth, 1,355 feet	1,245		110		with shale.
Lambton county, Petrolea :—					
Total depth, 1,505 feet	1,180		105		with shale.
	1,365		140		with shale.
Lambton county, Courtright :—					
Total depth, 1,665 feet	1,630		22		
Essex county, Windsor :—					
Total depth, Well No. 1, 1,167 feet	1,127		40		
Essex county, Windsor :—					
Total depth, Well No. 4, 1,672 feet	1,055		30		
	1,110		75		
	1,320		70		
	1,420		252		

The processes used in the production of salt in the Canadian field, are similar to those employed on the Michigan side of the salt area.

These processes may be divided into two general classes differing essentially as to the mode of evaporation of the brine. These are respectively evaporation in vacuum in a closed air tight vessel, and evaporation in an open pan. Each of these processes may again be subdivided, the first, evaporation in vacuum, into single effect and double effect evaporation; the second into direct fire evaporation and steam evaporation, each of which may be further differentiated according to the apparatus used. SALT, Deposits.

Vacuum pan process.

VACUUM PAN PROCESS.

The principle of this process is evaporation in a closed vessel in which a partial vacuum is maintained by means of an air pump. The reduction of atmospheric pressure causes evaporation to take place at a lower temperature; the crystallization is quicker and a finer grain is formed. The heat is obtained by steam entering a closed compartment in the interior of the vessel, in which are sets of copper tubes placed vertically. The steam surrounds these tubes through which the brine circulates. The object of the tubes, which are some five feet long and have a diameter of about three inches, is to give a greatly increased heating surface. When a sufficient quantity of salt has crystallized in the bottom of the vessel it is dumped out on the double bottom principle, without interrupting the evaporation.

The double effect is a modification by which the steam produced by the evaporation of one pan is made to circulate through the steam compartment of a second vessel. In this second vessel the vacuum is kept slightly higher, by which means the boiling point is lower than in the first pan. The principle of the double effect is therefore the use of the steam evaporated from the first pan as source of heat to produce the evaporation in the second pan, resulting in a great saving of fuel.

The only salt plant of this type in Canada is situated at Windsor, Ontario, and is worked by the Canadian Salt Co. This company, up to the present, has been operating two pans of the single effect type, but is now putting in a double effect apparatus which, when completed, will make it one of the best equipped salt manufacturing concerns of North America. The process followed at Windsor is briefly as follows:—

The wells from which the brine is obtained are from 1,167 to 1,672 feet deep, reaching the beds of solid rock-salt. They are cased with a ten inch tubing through the surface deposits; the tubing then narrows down to seven and a half inches, and eventually to six inches down to the salt-bed. Inside of the tubing is a pipe four and a half inches in

SALT.

Vacuum pan process.

diameter reaching down to the rock-salt. A powerful pump forces water down the outer tube; this dissolves the salt, eventually forming large cavities at the bottom of the well offering a great surface of salt to the action of the water. As the rock is not fissured or porous, and the head of the well is made watertight, the water forced downwards in the outer tube is charged to saturation point in the salt cavity and this brine is forced upwards through the inner tube. As a next step the brine flows into large wooden settling vats where it is heated to from 180 to 200° Fahrenheit, and allowed to settle for from twelve to twenty-four hours. By this operation, a great part of the sulphate of lime which is present in the rock-salt and held in mechanical suspension in the brine is deposited on the bottom of the vats. The brine is thus drawn off perfectly clear and limpid, and pumped into the vacuum pan. This large vessel has a cylindrical body with conical top and bottom. Its diameter is twelve feet, and its height about eighteen feet. It is divided horizontally into three compartments. The steam used as the source of heat for evaporation is admitted into the middle compartment, which is some five feet high and is made steam-tight. Passing through this middle compartment are sets of vertical copper tubes open at both ends and connecting the two other compartments in which the brine is admitted.

Direct steam from the boilers surrounds these tubes, which offer a great heating surface and through which the brine circulates freely. The vacuum in the pan is maintained by means of a powerful pump which at the same time draws off the steam produced by the evaporation. The salt falls to the bottom of the vessel and is emptied by means of a double valve without any interruption in the process. The vacuum is kept at twenty-eight inches mercury, which is very high. The main trouble encountered in this process is caused by the small quantity of gypsum or sulphate of lime contained in the brine. This impurity is deposited on the exterior of the tubes, coating them with a layer of non-conducting substance which has to be scaled off about every twelve hours. There are two pans, one being cleaned while the other is in operation. The Canadian Salt Co. is at present putting in very extensive additions to their plant, and when the improvements are completed their works will be better equipped than any other similar ones in America.

The most important improvement now being put in is a [illegible] which is said to be the largest in the world for the manufacture of salt. [illegible]

pans is obvious, as they will be used alternately, one being in operation while the other is being cleaned of the deposit of sulphate of lime. Thus the process will go on without interruption. The second effect pan can run continuously for at least a week without requiring cleaning. The diameters of the first and double effect pans are respectively twelve and twenty feet. The vacuum in the first pan is to be maintained at twenty-four to twenty-five inches, which lowers the boiling point to a temperature of 135° Fahrenheit, and in the second pan at twenty-eight inches, equal to a boiling point of ninety-two degrees. SALT. Vacuum pan process.

From the evaporation pan the salt is conveyed to the drying rooms where it is allowed to drain. It then passes into the dryer proper, which is a long wooden cylinder, the axis of which is slightly inclined to the horizontal with cleats and riffles placed longitudinally. Through this, currents of hot air circulate while it revolves, and the wet salt fed in at one end issues at the other end perfectly dry. It then passes through sieves of different sizes according to the grade of salt wanted, the finest passing through a fifty mesh screen.

The process as may be seen is very simple and yet very efficient. The Windsor plant compares very favourably with any plant on this continent. The steam is provided by two sets of boilers equipped with mechanical stokers, and capable of developing 1,700 horse power.

The capacity of the plant is at present 1,000 barrels a day; this, when the present improvements are completed, will be increased to 1,500 barrels per day. The present cooperage can turn out from 1,000 to 1,200 barrels a day.

STEAM EVAPORATION IN OPEN AIR. GRAINER AND RAKER PROCESS.

Steam evaporation in open air grainer and raker process.

This process was originally developed in Michigan and in that state is the one most used. In Ontario there are only three plants of this type now in operation, but the present tendency is toward a more extended use of this process and the abandoning of the more primitive direct fire manufacture.

The principle is simple in the extreme. The brine is pumped from the well into large wooden vats or tanks where it is heated and allowed to settle. Then it passes into the grainer proper. This consists of a long shallow vat made generally of boiler plates. The dimensions of the average grainer are 150 feet long by from 10 to 14 wide, and about 2 feet deep. Throughout the whole length of the vats are a number of steam pipes suspended by hangers, so as to leave the bottom smooth and clear of obstruction. One end of the

SALT.

Steam evaporation in open air grainer and raker process.

vat is sloping at an angle of about 20°, forming an apron. The brine, which is first heated in the settling vats is allowed to flow continuously into the grainers, where the level of the liquid is kept constant, at from 15 to 20 inches in depth. The evaporation causes the salt to crystallize, and settle over the bottom of the tanks. The steam used in the pipes of the grainer is, as a rule, live steam or direct from the boiler. To get as much efficiency as possible, the exhaust steam from these pipes is used to heat the brine in the settling tanks. To remove the salt from the grainers, a very ingenious device is used. It is a mechanical rake consisting of two endless chains running along the whole length of the grainer (from 140 to 160 feet) near the sides, over sets of rollers on horizontal axes. At equal intervals are fastened on these chains, vertical narrow blades, four or five inches wide, covering the entire width of the bottom of the vat. These blades, scraping up the salt as it forms and settles, bring it up the incline or apron at one end, giving the crystals a preliminary draining, then drop the salt on a draining and drying floor whence it is shoveled into bins.

At Kincardine a modification of this process is used which is called the "V" system. The only difference is in the shape of the graining vats. In the V system these graining vats have sloping sides in the shape ofthe letter V, and the salt when formed, falls to the bottom, which is made in the shape of a rectangular trough twelve inches wide by ten to twelve inches deep. The raker travels in the trough its dimensions being modified accordingly.

The grainer process is the favourite one in Michigan, and is at present spreading throughout the Ontario salt district. In several cases it is used by large lumber companies, who take up the manufacture of salt as a subsidiary industry, to use up the surplus and exhaust steam of their saw mills.

The process requires very little labour ; the installation of the plant is more costly than the old direct fire method ; but in the case of the lumber companies as the steam plant is primarily erected to supply the saw mills, very little extra expense in the boiler house is needed to supply the salt plant, and the two industries certainly go very well hand-in-hand.

Other steam evaporation processes.

OTHER STEAM EVAPORATION PROCESSES.

In other cases, the steam instead of being conveyed through pipes to evaporate the brine, is simply made to enter a false bottom under the evaporating vats. This is the case with a plant at Goderich, that of the Lake Huron and Manitoba Milling Co., who use the exhaust

SALT.

and surplus steam of their mill No mechanical rakers are used in this plant, the salt being removed with hand rakes. The output of this plant is at present one hundred barrels a day, but extensions are now in progress which, when completed, will double its capacity.

EVAPORATION BY DIRECT FIRE.

Evaporation by direct fire.

A plant of this type consists, besides the brine pumping apparatus, of settling tanks, evaporating pans and floor space to drain and pack the salt. The pans are as a rule 100 feet long by 20 to 25 feet wide and 12 to 14 inches deep; they are made of boiler plate, one quarter of an inch thick, and supported by walls which serve as sides to the fire grates and as horizontal flues along the whole length of the bottoms of the pans. These pans are made with the sides slanting forming a draining apron, on which the salt is raked from the bottom of the pans, as it crystallizes and deposits there. It is then stored in bins and packed in bags or barrels for shipment.

The plants using direct fire evaporation are, of course, the least costly to install and this type of manufacture is greatly used in the Ontario field. The capacity of the average plant is from 100 to 125 barrels of coarse salt per day. For this output from six to eight tons of coal is required, and seven to ten men.

There are at present twenty-one plants in the Ontario field, some of these run continuously and others only at intervals. Of these plants, sixteen use the direct fire evaporation, four have steam evaporation in open air, and one uses the vacuum process. The majority of these plants produce only the coarse packing salt. In fact only three plants in the whole district manufacture the finer grades of salt, which are classified as table, fine, dairy and cheese, according to their fineness. For the production of the better qualities, extra care has to be taken in the handling of the brine and of the salt. This has, moreover, to be dried artificially, and passed through the different mesh screens. There have been no attempts made towards mining rock salt in the district, but a company is at present sinking a shaft on the American shore of the Detroit river, some four miles below the city of Detroit. They hope to strike the first bed of salt at 800 feet. The progress of the enterprise will be watched with great interest.

Plants operating.

A list of the plants operating in the Canadian field is given below :—

Location.	Operated by.
Blyth	Young & Sparling.
Brussels	Coleman Salt Co.
Clinton	R. J. Ransford.
Courtright	" "

SALT.

Plants operating.

Location.	Operated by.
Exeter	Exeter Salt Co.
Goderich........................	North America Chemical Co.
"	Lake Huron & Manitoba Milling Co.
"	Peter McEwan.
Hensall	Geo. McEwan.
Kincardine........................	Rightmeyer Salt Co.
"	Ontario People Salt Mfg. Co.
Mooretown........................	Mooretown Salt Co.
"	Carter & Kittermaster.
Parkhill	Parkhill Salt Co.
Sarnia........................	Sarnia Salt Co.
"	Sarnia Bay Mills Co.
Sandwich	Saginaw Lumber & Salt Co.
Wingham	Young & Sparling.
Warwick........................	Elarton Salt Co.
Windsor........................	Canadian Salt Co.

Analyses.

ANALYSES OF BRINES.

—	Sodium Chloride.	Calcium Chloride.	Magnesium Chloride.	Sulphate of Lime.	Specific Gravity.	Degrees of Salometer.
Goderich, sample taken August 19, 1866....................	259·00	·432	·254	1·882	1·205	100
Goderich, same well as above, November 5, 1868............	236·410	·190	·410	4·858	1·187	92
Clinton well	204·070	·470	·184	5·583	1·157	80
Kincardine	241·350	·840	·230	3·264	1·191	94

Analyses by Dr. T. Sterry Hunt, laboratory, Geological Survey of Canada.

ANALYSES OF SALTS.

—	Sodium Chloride.	Magnesium Chloride.	Calcium Sulphate.	Water.	Insoluble.
Goderich (fine table salt)...	98·4238	0·0915	1·0426	0·6483	0·4200
" (fine salt)	98·0947	0·0010	1·2574	1·2610	....
" (coarse).........	97·3039	0·0436	1·4316	0·6454	..... .
Clinton (fine salt).........	98·5743	0·1368	1·1554	0·7944	0·0600
" (coarse).	97·4756	....	1·3899	0·9830	0·2200
Seaforth (dairy salt).......	98·7393	0·0168	1·3642	0·3289	0·0170
" (fine salt)........	97·8401	0·0480	1·1568	0·9095	0·0150
" (coarse)..........	98·2778	0·0078	1·2515	0·6832	0·0160

The above analyses of salt were made by Dr. Ellis, of Toronto.

The salt from which these samples were taken in all cases is manufactured in open pans.

SALT.

Salt industry in Michigan.

In Michigan the salt industry is well developed along the St. Clair and Detroit rivers. The salt is derived from the beds of the same formation as in Ontario. For the purpose of comparison the depths at which rock-salt is reached at different points in Michigan and the thickness of the beds are given below :

	Salt struck at depth of	Thickness of salt.	
Wayne county—Wyandotte......	800 feet.	30 feet.	
	940 "	15 "	
	1,120 "	70 "	
St. Clair county—Algonac.......	1,562 "	52 "	
" " 5 miles below town......	1,500 "	80 "	salt and shale mixed.
	1,605 "	18 "	
	1,633 "	94 "	
St. Clair county—St. Clair.......	1,630 "	30 "	
" Marine city....	1,700 "	over 100 "	
" Port Huron....	1,700 "	60 "	stopped in rock-salt.
Oakland county—Royal oak......	1,540 "	97 "	
	1,650 "	45 "	
	1,735 "	57 "	
	1,820 "	80 "	
	2,005 "	15 "	
	2,115 "	35 "	
	2,165 "	20 "	
	2,200 "	100 "	
	2,315 "	160 "	

Besides the beds of rock-salt, there is another source from which salt is manufactured in Michigan. This is the brine which is found in the porous beds at the base of the Carboniferous measures, and until the discovery of the rock-salt, which, in Michigan was later than in western Ontario, this brine was the only source of salt.

As mentioned before, no mining of the rock-salt beds is at present carried on ; but an attempt is now being made on the shore of the Detroit river a few miles below the city of Detroit, to reach the first bed of salt by a shaft with a view to working it by mining methods. It is expected that the bed will be met with at a depth of 800 feet.

Manitoba.

In Manitoba some brine springs have been worked for some length of time, supplying a small local demand. On the north-western part of Lake Winnipegosis, at Salt Point, near the mouth of Bell river, which empties into Dawson bay, salt was manufactured many years ago. The most important salt springs area, however, is that on Red Deer peninsula, in the southern part of Winnipegosis Lake. This was the scene of salt manufacture as early as 1820 or thereabouts, when James Monk-

SALT.
Manitoba.

man began working these springs. In every case, however, the process used was primitive, and the salt only used to supply local demands. After James Monkman, his sons took up the work, and in 1858, according to Professor H. G. Hind, they were carrying on the industry with profit.

Mr. J. W. Spencer, in the report of the Geological Survey of Canada for 1874 and 1875, gives a short description of how the manufacture was carried on at the time of his exploration in that district :

"The manufacture of the salt is conducted in a rude manner. Pits are dug four or five feet deep, and into them the waters infiltrate. Beside these, temporary furnaces are erected, on which are placed evaporating pans made of iron plate one-eighth of an inch in thickness and five or six feet long, by about three feet wide and eight or ten inches deep. Beside the pans, are trays into which the salt is raked. No pumps are used, the water being lifted into the pans directly from the pits by means of pails. The operation is conducted entirely in the open air. The manufactured salt is put into birch-bark boxes, or "mococks," holding about 100 pounds each, and is then ready for market. During the season Mr. McKay, the only person engaged in the business, made about 500 bushels, or less than half the quantity which had been manufactured in some previous years.

"The following is an analysis, by myself, of a sample of the salt which I brought from the works.

Sodium chloride	95·123
Magnesium chloride	0·600
Calcium sulphate	3·400
Sodium sulphate	0·394
Moisture	0·044
Residue	0·439
	100·000

"The residue consists of silica, alumina, iron and lime. The salt has a light brown tint, and is very coarse grained, owing to the manufacturer allowing the crystallization to go too far undisturbed."

J. B. Tyrrell, in his report on North-western Manitoba, (Geological Survey of Canada, 1890-1891, Part E), gives the following list of points where brine springs were observed :—

Salt Creek, west of Lake Dauphin.

Banks of Mossy river.

Salt Point, south of Lake Winnipegosis.

SALT. Manitoba

Monkmans Salt Springs, Red Deer peninsula.

Pine Creek.

Pelican Bay, mouth of Pelican creek.

Pelican Bay, west side.

Mouth of Bell river.

Salt Point.

Salt Point peninsula, with salt area near its base.

Salt Point peninsula, north side of its base.

Mouth of Steep Rock river.

Lower Red Deer river, many places.

Banks of Shoal river.

Mouth of Swan river.

These according to the same authority have their source chiefly in the Devonian rocks, although salt is not absent from the beds of Silurian age. The salt of these brine springs seems to be derived from crystals occurring scattered throughout the rocks rather than from beds of pure rock-salt, for impressions of salt crystals are very common in the dolomites, whereas no indications were observed from which the presence of rock-salt could be surmised. In some cases the crystals are so numerous that salt must have been present to the amount of one-third of the whole mass. As a rule the brine is not strong, but occurs in very large quantities.

Samples were collected and analyzed in the laboratory of the Geological Survey of Canada and from these tests the following table has been made up :—

SALT.

Analyses of brines from Manitoba.

ANALYSES OF BRINES FROM MANITOBA.

The following table shows the number of grains per Imperial gallon of each of the chief constituents :—

Constituents.	1	2	3	4	5	6	7	8	9	10	11	12
Chloride of Sodium..	3426.61	2777.44	3402.38	3716.73	3884.57	3673.23	6024.98	3233.15	3709.59	1873.78	1347.08	3099.41
" of Potassium.	163.86	114.59	209.39	180.21	137.90	14 .16	86.17	138.81	179.86	150.16	48.72	23.11
" of Calcium ..	....	28.45	....	....	....	7.87	....	10.43	....	15.67	....	44.05
" of Magnesium	77.17	101.16	101.75	85.69	47.43	94.66	125.46	78.03	81.46	79.84	58.53	142.22
Sulphate of Lime....	285.83	233.72	296.23	304.96	272.81	300.30	425.25	281.90	308.38	205.53	204.83	252.71
" of Magnesia.	3.42	....	1.24	6.49	57.30	....	19.42	....	10.98	....	10.95	....
Total	3956.89	3255.37	4010.99	4294.08	4400.01	4221.22	6681.28	3742.32	4290.27	2324.98	1670.11	3561.50
Specific gravity......	1.039	1.032	1.039	1.041	1.044	1.041	1.063	1.035	1.039	1.022	1.016	1.035

1. Spring on the south bank of Red Deer river, four miles from Lake Winnipegosis. N. lat. 52° 52′ 30″ ; W. long. 101° 5′. Flow 10 gallons a minute, collected 9th Sept. 1889.

2. Lower Salt spring, on the north side of Red Deer river, a mile and three quarters above its discharge into Lake Winnipegosis. N. lat. 52° 53′ 20″; W. long. 101° 2′ 15″. Flow 2 gallons a minute. Collected, 13th August, 1889.

3. Spring near the west shore of Dawson Bay, Lake Winnipegosis, three quarters of a mile north of Steep Rock river. N. lat. 52° 48′ 30″; W. long. 100° 57′. Flow 4 gallons a minutes, Collected, 6th August 1889.

4. Spring on a hill side near the shore of Dawson bay, Lake Winnipegosis, at a point two miles east of the mouth of Steep Rock river. N. lat. 52° 48′ 30″ ; W. long. 100° 0′ 57″. Flow 25 gallons a minute. Collected August 8th 1889.

5. Salt Point, on the south-west shore of Dawson Bay, Lake Winnipegosis. N. lat. 52° 48′; W. long. 100° 48′. Flow $1\frac{1}{2}$ gallons a minute. Collected August 3rd, 1889.

6. Spring on the west side of Dawson Bay, Lake Winnipegosis, three miles and a half north of the mouth of Bell river, and a mile back from the lake shore. N. lat. 52° 48′; W. long. 100° 51′ 20″. Flow 20 gallons a minute. Collected 2nd August 1889.

7. Brook flowing into the west side of Dawson Bay, Lake Winnipegosis. N. lat. 52° 47′ 40″; W. long. 100° 51′. Flow 60 gallons a minute. Collected 1st August 1889.

8. Spring half a mile back from the west shore of Swan lake, between it and the lower portion of Swan river. N. lat. 52° 26′ 35″; W. long. 100° 42′ 45″. Flow 5 gallons a minute. Collected August 31, 1889.

9. Spring on the shore of Pelican Bay, Lake Winnipegosis, just east of the mouth of Pelican river. N. lat. 52° 38′ 30″; W. long. 100° 21′. Flow 25 gallons a minute. Collected 21st July 1889.

10. Spring on the west side of Pine Creek, near its discharge into Lake Winnipegosis. N. lat. 52° 1′; W. long. 100° 8′. Collected 6th July 1889.

11. Monkman's Salt Springs, on the west shore of Lake Winnipegosis. N. lat. 51° 45′; W. long. 99° 56′ 40″. Collected 1st July 1889.

12. Monkman's Salt Springs, an old well a few yards from the spring from which No. 11 was obtained. Collected 1st July 1889.

SALT.

Manitoba.

Of these brines, Dr. G. C. Hoffmann reports as follows:—"The proportion of foreign saline matter in these brines is not excessive and if certain purifying processes are had recourse to, there is no reason, local conditions being favourable, why they should not be utilized in the manufacture of salt."

At present the industry is carried on at intervals on a small scale supplying only local demand. J. B. Tyrrell describes the saline areas as follows:—"The characters of these saline areas are very similar throughout, and the descriptions already given of those on Pelican bay and other places might suffice for all. They are generally barren tracts several acres in extent, surrounded by a fringe of the red salt plant (*Salicornia herbacea*). Here and there springs bubble up and often build rounded mounds of reddish scinter, several feet in height, in the centre of the tops of which, over the springs, are little basins of clear brine. Down the sides of these mounds the water trickles to the arid flats, where it evaporates in the dry seasons. In other places the pool of salt water is in the middle of a little tract of soft mud, over which may be a sod of coarse grass. In the pool bubbles of gas are constantly rising. This gas was found to be uninflammable, and was probably to a large extent composed of air."

Assiniboia.

Further west in the Assiniboia district, saline lakes occur. Mr. R. G. McConnell reports the presence of a great many of these in the plain north, stretching from the escarpment which ends the Cypress Hills on towards the Saskatchewan River. These lakes are of all sizes, among the largest are Many Island lake, Crane lake, Big Stick lake. "The lakes vary through every degree of salinity, from those covered with a thick crust of crystallized salts down to others in which the water is perfectly fresh, and the two extremes are not infrequently met with side by side."

Bibliography.

BIBLIOGRAPHY.

BAILEY, L. W.—Rep. Geol. Surv. of Canada, Vol. X, 1897, part M, The Mineral Resources of the Province of New Brunswick.

BRUMELL, H. P. H.—Rep. Geol. Surv. of Canada, Vol. V, 1890-91. Part Q, Report on the Natural Gas and Petroleum in Ontario.

FLETCHER, HUGH.—Rep. Geol. Surv. of Canada, 1886, part P. On Geological Surveys and Explorations in counties of Guysborough, Antigonish, Pictou, Colchester and Halifax, Nova Scotia.

HOFFMANN, G. C.—Report Geol. Surv. of Canada, Vol. V., 1890-91. Analyses of Brines from Manitoba.

HUNT, T. S.—Geol. Surv. of Canada, Report of Progress, 1865-66. Geology of Petroleum and Salt.

HUNT, T. S.—Geol. Surv. of Canada, Report of Progress
Salt Region.

HUNT, T. S.—Geol. Surv. of Canada, Report of Progr
Salt Region.

HUNT, T. S.—Trans. Am. Inst., Mining Engineers, Vol.
Region.

INGALL, E. D.—Rep. Geol. Surv. of Canada, Vol. I, (N.S

LANE, A. C.—Geological Survey of Michigan, Report for

McCONNELL, R. G.—Rep. Geol. Surv. of Canada, 1885,
Hills, Wood Mountain and adjacent cou

MERRILL, F. J. H.—Bulletin of the New York State M
Salt and Gypsum industries of New Yor

MINERAL INDUSTRY.—Technology and Trade, New York

MINES SECTION.—Reports Geol. Surv. of Canada, Vol. I
91; Vol. VI., 1892-93; Vol. IX., 1896
and developments of the industry.

ONTARIO BUREAU OF MINES.—Reports of: Vol. I., 1891;
1896; Vol. IX, 1899.

SMITH, J. S.—Geol. Surv. of Canada, Report of Progr
Statistics of the Trade and Manufacture

SPENCER, J. W.—Geol. Surv. of Canada, Report of P
Country between Upper Assiniboine riv
and Manitoba.

TYRRELL, J. B.—Rep. Geol. Surv. of Canada, Vol. V., 18
Northwestern Manitoba.

WRIGHT AND LANE.—Geology of Lower Michigan, with
Geological Survey of Michigan, Vol. V.

ZINC.

The only production of zinc in 1902 of whicl
was from one mine in Olden township, Ontario
ore were raised valued at $11,500 or a little over
158 tons of ore, averaging about 45 per cent
Swansea, Wales, the balance being left at the
during the following season. The metallic zinc
shipped amounted to about 142,200 pounds whic
New York market price of the metal would be

Zinc.

Production.

TABLE 1.

ZINC.

ANNUAL PRODUCTION OF ZINC.

Calendar Year.	Pounds.	Value.
1898	788,000	$ 36,011
1899	814,000	46,805
1900	212,000	9,342
1901	....	....
1902	142,200	6,882

TABLE 2.

ZINC.

Imports.

IMPORTS OF ZINC IN BLOCKS, PIGS AND SHEETS.

Fiscal Year.	Cwt.	Value.	Fiscal Year.	Cwt.	Value.
1880	13,805	$67,881	1892	21,881	$127,302
1881	20,920	94,015	1893	26,446	124,360
1882	15,021	76,631	1894	20,774	90,680
1883	22,765	94,799	1895	15,061	63,373
1884	18,945	77,373	1896	20,223	80,784
1885	20,954	70,598	1897	11,946	57,754
1886	23,146	85,599	1898	35,148	112,785
1887	26,142	98,557	1899	18,785	107,477
1888	16,407	65,827	1900	28,748	156,167
1889	19,782	83,935	1901	20,527	103,457
1890	18,236	92,530	1902 Duty free	34,871	141,560
1891	17,984	105,023			

TABLE 3.

ZINC.

IMPORTS OF SPELTER.

Fiscal Year.	Cwt.	Value.	Fiscal Year.	Cwt.	Value.
1880	1,073	$ 5,310	1892	13,909	62,550
1881	2,904	12,276	1893	10,721	49,822
1882	1,654	7,779	1894	8,423	35,615
1883	1,274	5,196	1895	9,249	30,245
1884	2,239	10,417	1896	10,897	40,548
1885	3,325	10,875	1897	8,342	32,826
1886	5,432	18,238	1898	2,794	13,561
1887	6,908	25,007	1899	5,450	29,687
1888	7,772	29,762	1900	5,836	29,416
1889	8,750	37,403	1901	14,621	58,283
1890	14,570	71,122	1902* Duty free	18,356	80,757
1891	6,249	31,459			

*Spelter in blocks and pigs.

TABLE 4.

ZINC.

IMPORTS OF ZINC, MANUFACTUR

Fiscal Year.	Value.	Fisca
1880	$ 8,327	1891
1881	20,178	1892
1882	15,526	1893
1883	22,599	1894
1884	11,952	1895
1885	9,459	1896
1886	7,345	1897
1887	6,561	1898
1888	7,402	1899
1889	7,233	1900
1890	6,472	1901

1902 { Zinc seamless drawn tubing	
" manufactures of, N.O.P	
Total	

The production and sale of zinc-ores may definite and interesting feature of the mineral in as shown by the following extract from the Re Mines of British Columbia for 1902 :—

'Formerly, zinc in the silver-lead ores in the the smelters having exacted a penalty for its pr being sought after by the American zinc smelte paid for it which will enable the shippers to re modity they had looked upon as being not only A number of mines, notably among them the P Star and some others have availed themselves shipping a considerable quantity of the ore to is being treated. Preparations are also being of the mills, for the better separation of the that a number of other mills will be built, durin for the proper and more economical handling of

ZINC-ORE DEPOSITS.

The zinc ores of Canada have so far received the work of exploiting them has been spasmodi been during the last few years that any attentic matter, the present awakening of interest bein ble demand for zinc ores which has lately arisen

Zinc. Ores.

So far as discovery has yet gone, in eastern Canada deposits of workable zinc ores are few. Zinc blende occurs, however, at many points accompanying galena, and in British Columbia a commencement has been made in shipping it to smelters both in the United States and in Belgium. Blende as an associated mineral is of frequent occurrence in Canada in veins worked for gold, silver and copper.

The possibilities for profitable working of some of our zinc ores have been largely increased, owing to the growth in the demand due doubtless to the general commercial activity characterizing the last few years. Ores of this metal, other than blende, have not as yet been proved to exist in Canada in economic quantities.

Taking the separate parts of the Dominion, little is on record as to economic deposits of these ores in Nova Scotia, but blende in small quantities occurs in many of the gold-bearing quartz veins in that province.

In this connection the following information is furnished by Mr. F. H. Mason, F.G.S. Analyst etc., of Halifax Nova Scotia.

"The only deposit of zinc blende that has any economic possibilities that I know of in Nova Scotia, is that owned by the Cheticamp Gold Mining Company situated at Faribault brook, a branch of the Cheticamp river, Inverness Co. C.B. It occurs in a bed of sericite schist some 20 feet in thickness and is associated with pyrrhotite, mispickel and galena. The mineral occurs in bands through the schist and is in places quite massive. I have seen lenses over 2 feet in thickness. A slope 45 feet deep has been sunk upon it. I have found that by crushing to about ¼ mesh and roasting prior to concentration a fairly clean galena and blende concentrate may be obtained."

In New Brunswick and Quebec, sphalerite also occurs as an associate mineral in veins carrying galena, but as extensive mining operations have never been carried on continuously, none is produced even as a by-product. In the latter province the only point at which zinc was claimed to occur in anything like commercial quantities is on the property of the Grand Calumet Mining company. This is situated on lot 10 range IV. Calumet island, Pontiac county, Que., at a point on the Ottawa river about 50 miles above Ottawa city. It exists at this place in deposits in the Laurentian rocks of the district. They were described in 1898 by Dr. R. W. Ells of the Geological Survey staff as follows :—

"The most important mining developments along the lower Ottawa at present are on Calumet island. Here the old workings on the

Lawn property, near the east end of the i
galena deposits, have been extended and de
carried on over three lots on Range IV. Th
largely dioritic with some reddish granite, anc
sive through the grey gneiss and limestones
exposed along the Roche Fendue channel of th
side of this island. The principal workings at
known as the Bowie property, where a large op
an ore-body in the diorite consisting of both ble
body is of considerable extent, but is pockety
well defined hanging or foot walls were seen, t
spurs into the enclosing diorite. Over 1,000
at this place during the past summer, and it
European market. On the west part of the
sunk to a depth of nearly 130 feet, in order to
several masses of ore that appear at the surfa
work on this location was suspended during th
orders from the Bowie pit. There is eviden
mixed blende and galena ores in the intrusi
but in none of the openings examined was any
ture noted, the ore every where appearing ra
though some of these are of large extent."

In Ontario also numerous deposits of galen
or less zinc blende are known to exist. These,
time to time in past years, have not so far bee
nent working basis, so that although blende i
duced as a by-product it cannot as yet be counte
alone. A few examples of these which have r
years, may be here mentioned.

The Katherine lead and zinc mine is situat
Lake township, Hastings county, 3 miles fr
development work was done at this place duri
and Colonial Mining and Development con
described in the Report of the Ontario Bur
the vein is said to carry galena and zinc blend
of the ore shewing 10 ounces of silver to th
that the vein is in diorite and has a width va
feet. Up to 1900 two shafts had been sunk,
feet, and another at about half a mile from thi
Diamond drilling had been carried to a depth

Zinc. Ores.

A zinc mine is being operated on lots 5 and 6 Con. III. in the township of Olden, Frontenac county, at a point about a mile north of Long lake. According to Dr. W. G. Miller provincial, mineralogist, the deposit is irregular in character, occurring in crystalline limestone. The ore consists of a mixture of zinc blende and galena and averages after rough cobbing about 40 per cent of zinc, 12 to 15 per cent of lead, and the pure galena carries about 20 ounces of silver to the ton of 2,000 lbs. The owners state that about 950 tons of ore were raised prior to the end of 1902, of which a trial shipment of 158 tons was made to Swansea, England. Up to that date, a shaft had been sunk to a depth of 80 feet on a 2 feet rib of good ore.

At Blende lake, about two miles north of the eastern end of Thunder bay, Lake Superior, blende in large crystals occurs in a vein of coarse calcite about eight feet in width. The south wall of the vein, which runs east and west, consists of dioritic schist of Huronian age, while the north wall is formed by ferruginous and silicious clay slates of the Animikie Series.

In the Thunder bay district the silver veins which were extensively worked some years ago, carried considerable blende in places. At some of the mines this mineral, when enriched by the secondary minerals, argentite and native silver, constituted the main constituent of these ore bodies, although at most of them it would simply be an accessory constituent of the vein. The Silver Mountain vein is the only one which has been worked of late, most of the other mines having been idle for a number of years.

The only zinc deposits proper which have so far been developed to any extent in Canada are located in Ontario near Rossport station on the Canadian Pacific Railway, on the north shore of Lake Superior. The Zenith mine is situate some 12 miles north of the lake shore, at the head waters of the White Sand river. Access is had to it in summer by canoeing up the river and the chain of small lakes along its course. In winter, better communication is to be had over the ice by means of a road connecting these sheets of water.

The deposits seem to consist of more or less irregular bodies of sphalerite in the hornblendic and dioritic Huronian rocks of the vicinity. When visited by Mr. E. D. Ingall for the Geological Survey in 1884, the work done had not been of sufficient extent to allow of positive conclusions being arrived at as to their real nature. A number of surfaces of ore had been exposed at different points on the property in following up the surface indications by the removal of the capping of earth or solid rock under which they had been found to pass.

The ore exposures consisted of one on th
side and the other near the base on the othe
little lake. The hill is about 75 feet in hei
At neither point had the limit of the ore bee
and therefore such features as the strike, di
definitely be determined. At the lower work
had been exposed, measuring about 20 feet x
about 90 feet to the south east of this me
Easterly from the main stripping about 30 f
show the existence of a small vein about six i
N.E. dipping 45° N.W. and a small parallel
further west again. The upper workings ar
these. At the time of the visit above menti
solid blende about 15 feet x 20 feet had be
The formation strikes about W.N.W. and
In an easterly direction from the exposure tl
underlie a capping of country rock. Althou
be formed at that time and under the conc
impression was formed, from the features pre
from the minute structure of some of the ore
as masses coinciding with the foliation of the
thus follow it in all its flexures. If this be th
in the sharper bends to find large irregular n
with thinner sheets in the less folded portions
explain the peculiar features of the ore su
especially the upper one, where it would appe
had uncovered one of these bends from abo
overlying rock representing the upper portion

Indications of other occurrences in the
alluded to, were also noted The foliated st
not always plainly apparent, being confused b

The blende is dark coloured and the associat
copper and iron pyrites and here and there
copper also a white incrustation on the weat
sulphate of zinc from oxidation of the ore.

Although the existence of ore at this plac
20 years ago, owing to its inaccessibility it w
winter of 1898–99. Operations were then con
year or two, but the mine is now idle. The tot
as per returns received at this office, was 1065
description of the progress made at the mine

Zinc. Ores.

the Ontario Government Inspector of mines as follows:—To Feb. 21, 1900, three shafts had been sunk; No. 1, 35 feet deep; No. 2, 40 feet deep; No. 3, 12 feet deep. A small open cut had also been made, from which about 100 tons of ore had been taken. All the shipments were made in the winter by hauling the ore over the ice on the lakes and on the connecting stretches of road which had been cut out for the purpose. Freighting from the mine to the railroad is said to have cost about $2.00 per ton.

Speaking of his visit to this place on Feb. 14, 1901, the mining inspector describes the condition of things as follows;—

"Mining operations since a year ago have been confined to driving a tunnel into the hill in which the zinc blende deposits occur, starting on the level of the small lake at the foot at a point between the old shafts, about 100 feet north of No. 1 and 500 feet south of No. 2 and beneath the old open stope in the brow of the bluff. The length to date is 75 feet, including 18 feet of open cut at the mouth, and in its course of about northeast, the tunnel is intended to crosscut to the main veins found on the surface as well as to explore the country rock.

"In the open cut, a large body of zinc blende was struck and stoped up 15 feet to the surface, in places 4 and 5 feet wide, but of very irregular shape, and without any visible continuous walls. At 12 feet in the tunnel another band of solid blende a foot wide runs down into the floor, and at 30 feet beyond this is a third body, 15 inches wide at first but pinching out in ten feet at the face. Besides these three main strikes, many other intermediate stringers and veins from a fraction to 10 inches wide were passed, all having approximately the same strike of north and south and dip of about 25 degrees east, into the hill, which bearings coincide with those of the outcropping of the large vein at the surface above. The country rock as seen in the tunnel has been disturbed and broken up along two directions, giving it a "blocky" appearance, the main movement having been sufficient to produce schistose areas in widths from streaks up to several feet, striking north and south with dip 25 degrees east, which directions are the same as those of the ore-bodies. In fact it is in this schist, altered in places from the coarse green trap rock to a soft gouge that most of the veins have been found.

"Grains of zinc blende occur imbedded in the massive trap, having no connection with the main deposits; frequently also masses of the sulphides, pyrites, prrrhotite and chalcopyrite, are exposed in the seams, both separate from and contiguous to the blende. The massive zinc blende in the tunnel workings contains small grains of pyrites and

ZINC. Ores.

writer from the examination made in 1884 and because a right understanding of the conditions at this place, where the ore-bodies have been worked out, will be very helpful in future in judging the possibilities of other similar deposits found in the district.

Indications of the existence of a number of other bodies of zinc ore are reported from the district around the Zenith mine, and a number of mineral locations have been taken up. On one of these viz. E.S. 79, some development work has been done. This is known as the Gesic mine. The shaft, at the time of the visit of the Ontario Inspector of Mines in February 1900, had been sunk some 23 feet on a shear zone in the "country rock," showing a little mineralization; but he reports the bottom as showing ore in promising quantities.

At Mazokama River, about 25 miles further west, on the main line of the Canadian Pacific Railway, it is reported that zinc blende has been found.

In a strong vein known as Johnston's mine, which also holds galena at Wolf river, north-west of the head of Black bay, Lake Superior, bunches of blende are scattered through the gangue, which consists of calcspar and quartz.

At the Victoria and the Cascade Mines, Garden river, near Sault Ste. Marie, which were worked in past years primarily for galena, a considerable proportion of blende occurs along with it.

Isolated crystals of blende, generally of a light colour, occur in the dolomite of the Guelph formation from the falls of Niagara to the township of Beverley at the head of Lake Ontario.

So far as our present knowledge extends, British Columbia will prove to be the chief source of zinc ores in Canada. In the silver-lead mining districts of East and West Kootenay, zinc blende in varying proportions occurs as an associate mineral with the galena, and in mining, the blende is produced as a by-product. Whilst in some of the mines and districts, blende forms quite a sub-ordinate feature of the veins, in others it exists in quite large proportion.

During 1902 considerable interest was aroused in the province in regard to this mineral owing to the visits of agents of smelter firms in the United States seeking zinc ores. Some difficulty was anticipated in profitably marketing the product on account of high freight and the duty on the ore entering the United States. It is now reported however that favourable arrangements have been arrived at regarding both these points and that shipments of the mineral to the American smelters from the Slocan mines have commenced.

Blende is associated with the galena found i
of Great Slave lake, N.W.T.*

STRUCTURAL MATER

Under this heading are comprised building
slates, flagstone, cements, lime, &c., as well
clay, which include building bricks, tiles, dra
coarse pottery.

The industries based on the structural ma
and are carried on in so many different plac
often intermittently, that it is impossible
complete returns of quantity or value of p
production are, therefore, to be taken only as

TABLE 1.

STRUCTURAL MATERIALS.

ANNUAL PRODUCTION OF BUILDIN

Calendar Year.
1886
1887
1888
1889
1890
1891
1892
1893
1894
1895
1896
1897
1898
1899
1900
1901
1902

*See Dr. Bell's Summary Report for 1899.

STRUCTURAL MATERIALS.

Exports.

TABLE 2.

STRUCTURAL MATERIALS.

EXPORTS OF STONE AND MARBLE, WROUGHT AND UNWROUGHT.

Calendar Year.	Wrought.	Unwrought.
1890	$21,725	$43,611
1891	13,398	46,162
1892	7,698	47,424
1893	9,102	12,532
1894	22,576	34,130
1895	8,587	51,616
1896	4,934	32,897
1897	9,415	42,034
1898	2,526	65,370
1899	5,092	101,931
1900	5,933	115,711
1901	5,917	157,739
1902	8,632	124,829

TABLE 3.

STRUCTURAL MATERIALS.

Imports.

IMPORTS OF BUILDING STONE.

Calendar Year	Value.	Calendar Year.	Value.
1880	$ 35,970	1891	$170,890
1881	58,149	1892	95,550
1882	33,623	1893	56,510
1883	35,061	1894	52,908
1884	51,088	1895	44,282
1885	30,491	1896	54,130
1886	41,675	1897	38,714
1887	54,368	1898	28,495
1888	86,373	1899	48,040
1889	100,314	1900	64,533
1890	132,155	1901	46,078

1902	Flagstones, granite and rough freestone, sandstone, and all building stone, not hammered or chiselled. Duty 15 p.c.	$69,972
	Granite and freestones, dressed; all other building stone dressed, except marble. Duty 20 p.c.	29,102
		$99,074

TABLE 4.

STRUCTURAL MATERIALS

IMPORTS OF MANUFACTURES OF STONE OR

Fiscal Year.	Value.	Fis
1880	$29,408	1891
1881	36,877	1892
1882	37,267	1893
1883	45,636	1894
1884	45,290	1895
1885	39,867	1896
1886	41,984	1897
1887	41,829	1898
1888	47,487	1899
1889	61,341	1900
1890	84,396	1901

1902	Granite—Sawn only
	" Finished and polished
	" Manufactures of N.O.P
	Paving blocks
	Manufactures of stone, N.O.P

TABLE 5.

STRUCTURAL MATERIALS.

ANNUAL PRODUCTION OF MA

Calendar Year.	T
1886	
1887	
1888	
1889	
1890	
1891	
1892	
1893	
1894	
1895	
1896	
1897 to 1901 inclusive.	

STRUCTURAL MATERIALS.

Imports of Marble.

TABLE 6.

STRUCTURAL MATERIALS.

IMPORTS OF MARBLE.

Fiscal Year.			Value.
1880			$ 63,015
1881			85,977
1882			109,505
1883			128,520
1884			108,771
1885			102,835
1886			117,752
1887			104,250
1888			94,681
1889			118,421
1890			99,353
1891			107,661
1892			106,268
1893			96,177
1894			94,657
1895			83,422
1896			90,065
1897			77,150
1898			95,894
1899			101,879
1900			94,017
1901			96,159
		Duty.	
1902	Marble and manufactures of :—		
	Marble sawn only	20 %	$87,077
	Finished and polished	35 %	11,828
	Rough, not hammered or chiselled	15 %	9,537
	Manufactures of, N.O.P.	35 %	21,982
	Total, marble and manufactures of		$130,424

Production of Granite.

TABLE 7.

STRUCTURAL MATERIALS.

ANNUAL PRODUCTION OF GRANITE.

Calendar Year.	Tons.	Value.	Calendar Year.	Tons.	Value.
1886	6,062	$63,309	1895	19,238	84,838
1887	21,217	142,506	1896	18,717	106,709
1888	21,352	147,305	1897	10,345	61,934
1889	10,197	79,624	1898	23,897	81,073
1890	13,307	65,985	1899	13,418	90,542
1891	13,637	70,056	1900		80,000
1892	24,302	89,326	1901		155,000
1893	22,521	94,393	1902		210,000
1894	16,392	109,936			

TABLE 8.

STRUCTURAL MATERIALS.

ANNUAL PRODUCTION OF SLAT

Calendar Year.	Tons.
1886	5,345
1887	7,357
1888	5,314
1889	6,935
1890	6,368
1891	5,000
1892	5,180
1893	7,112
1894	....
1895	....
1896	....
1897	....
1898	....
1899	....
1900	....
1901	715
1902	....

TABLE 9.

STRUCTURAL MATERIALS.

EXPORTS OF SLATE.

Calendar Year.	Tons.	Va
1884	539	$6
1885	346	5
1886	34	
1887	27	
1888	22	
1889	26	3
1890	12	
1891	15	
1892	87	2
1893	178	3
1894	187	3
1895	36	
1896	301	8
1897	Nil.	.
1898	Nil.	.
1899	Nil.	.
1900	Nil.	.
1901	16,750	10
1902	....	......

STRUCTURAL MATERIALS.

Imports of Slate.

TABLE 10.

STRUCTURAL MATERIALS.

IMPORTS OF SLATE.

Fiscal Year.	Value.	Fiscal Year.	Value.
1880	$21,431	1891	$46,104
1881	22,184	1892	50,441
1882	24,543	1893	51,179
1883	24,968	1894	29,267
1884	28,816	1895	19,471
1885	28,169	1896	24,176
1886	27,852	1897	21,615
1887	27,845	1898	24,907
1888	23,151	1899	33,100
1889	41,370	1900	53,707
1890	22,871	1901	72,187

Year	Article	Duty.	Value
1902	Slate and manufactures of—		
	Mantels	30 %	$ 171
	Rooting slate	25 % not over 75c per square	37,390
	School writing slates	25 %	13,734
	Slate pencils	25 %	3,481
	Slate of all kinds and manufactures of, N.E.S.	30 %	17,825
	Total		$72,601

Production of Flagstone.

TABLE 11.

STRUCTURAL MATERIALS.

ANNUAL PRODUCTION OF FLAGSTONE.

Calendar Year.	Quantity, Sq. ft.	Value.
1886	70,000	$ 7,875
1887	116,000	11,600
1888	64,800	6,580
1889	14,000	1,400
1890	17,865	1,643
1891	27,300	2,721
1892	13,700	1,869
1893	40,500	3,487
1894	152,700	5,298
1895	80,005	6,687
1896	....	6,710
1897	....	7,190
1898	....	4,250
1899	....	7,600
1900	....	5,250
1901	....	4,575
1902	87,300	7,760

TABLE 12.

STRUCTURAL MATERIALS.

IMPORTS OF FLAGSTONE.

Fiscal Year.	Tons.	Value.	Fiscal Ye
1881	23	$ 241	1892
1882	90	848	1893
1883	10	99	1894
1884	137	1,158	1895
1885	205	1,756	1896
1886	1,602	9,443	1897
1887	1,316	10,966	1898
1888	2,642	21,077	1899
1889	1,669	15,451	1900
1890	5,665	48,995	1901
1891	3,770	36,348	*1902

* Flagstones dressed. Duty, 20 %. (S

Cement.—The production of cement in Can
ural rock and Portland, amounted to a total of
at $1,127,550 as compared with 450,394 barrel
1901 and 417,552 barrels valued at $662,910
figures represent actual sales and shipments. T
in 1902 as compared with 1901 was 272,131
cent.

TABLE 13.

STRUCTURAL MATERIALS.

ANNUAL PRODUCTION OF CEME

Calendar Year.	Barrels.	Value.	Calendar Ye
1887	69,843	$ 81,909	1892
1888	50,668	35,593	1893
1889	90,474	69,790	1894
1890	102,216	92,405	1895
1891	93,473	108,561	1896

		Barrels.	Valu
1897	Naturel	85,450	$ 65,
	Portland	119,763	209,
1898	Naturel	87,125	73,
	Portland	163,084	324,
1899	Naturel	141,387	119,
	Portland	255,366	513,
1900	Naturel	125,428	99,
	Portland	292,124	562,
1901	Natural	133,328	94,
	Portland	317,066	565,
1902	Natural	127,931	98,
	Portland	594,594	1,028,

STRUCTURAL MATERIALS.

Natural Rock Cement.

Natural Rock Cement was made by four firms in Ontario and one in Manitoba, and the production in 1902 was as follows:—

Total sales during the year 124,400 barrels, valued at $91,870.
Total manufactured during the year 131,400 barrels.
Stock in manufacturers hands 1st June, 1902, 19,400 barrels.
" " " 31st Dec., 1902, 24,600 "

The prices realized at the works were from 70 to 80 cents per barrel of 240 lbs. net, in Ontario, while in Manitoba $2.00 per barrel of 200 lbs. was obtained.

Following is a list of producing firms:—

The Hamilton Cement Works, Hamilton, Ont.

The Queenston Cement Works, Queenston, Ont.

Battle's Thorold Cement Works, Thorold, Ont.

The Toronto Lime Company, Toronto, Ont.

The Manitoba Union Mining Co., Ltd., Winnipeg, Man.

The total capacity of the works of the above companies is about 800 barrels per day, or 240,000 barrels per year of 300 days. The plants were apparently operated to only about 60 per cent of their capacity during 1902.

Portland Cement.

Portland Cement was made by eight companies, one in Quebec and seven in Ontario, and the total production for 1902 was as follows:—

Total sales during the year 594,594 barrels valued at $1,028,618.
Total manufactured during year 562,335 barrels.
Stock in manufacturers hands 1st June, 1902, 65,705 barrels.
" " " 31st Dec., 1902, 33,446 "

The prices realized at the works ranged from $1.57 to $2.00 per barrel of 350 lbs. net.

The total capacity of the eight works in operation during the year was about 3,000 barrels per day or 900,000 barrels a year of 300 days, so that the output for the year was less than 63 per cent of the capacity; it should be noted however that two of the works were in operation for a few months only.

The imports of Portland cement for the year were (see table 17) 1,971,616 cwt. valued at $833,657. This would represent about 492,-904 barrels of 400 lbs.

Adding the imports to the sales we have an estimated consumption of Portland cement in Canada in 1902 of 1,087,498 barrels.

Following is an estimate of the consumption
Canada for the past six years :—

——	Canadian.	Import
	Barrels.	Barrel
1897	119,763	210,
1898	163,084	268,
1899	225,366	325,
1900	292,124	325,
1901	317,066	403,
1902	594,594	492,

Following is a list of Portland cement compan

Companies producing cement in 1902 :—

Crescent Cement Works, Longue Point, Qu

Canadian Portland Cement Company, Dese

Lakefield Portland Cement Co., Lakefield,

Imperial Cement Co., Ltd., Owen Sound, O

Owen Sound Portland Cement Co., Ltd., O

Grey and Bruce Portland Cement Co., Ltd.

Sun Portland Cement Co., Ltd., Owen Sou

Hanover Portland Cement Co., Ltd., Hano

Companies with works completed or in proces
panies proposing to erect plants :—

National Portland Cement Co., Toronto an

International Portland Cement Co., Toront

Colonial Portland Cement Co., Wiarton, On

Belleville Portland Cement Co., Belleville,

Raven Lake Portland Cement Co., Toronto a

Ontario Portland Cement Co., Brantford, O

Superior Portland Cement Co., Orangeville,

St. Mary's Portland Cement Co., Orangevil

Standard Portland Cement Co., Toronto, O

Royal Cement Co., Montreal, Que.

Western Portland Cement Co., Winnipeg, M

Manitoba Portland Cement Co., Winnipeg,

STRUCTURAL MATERIALS.

Cement.

Exports.

TABLE 14.

STRUCTURAL MATERIALS.

EXPORTS OF CEMENT.

Calendar Year.	Value.
1891	$ 2,881
1892	938
1893	1,172
1894	482
1895	937
1896	1,328
1897	644
1898	2,117
1899	2,733
1900	3,296
1901	1,514
1902	2,267

Imports.

TABLE 15.

STRUCTURAL MATERIALS.

IMPORTS ON CEMENT IN BULK OR BAGS.

Fiscal Year.	Bushels.	Value.	Fiscal Year.	Bushels.	Value.
1880	65	$ 28	1892	14,351	3,394
1881	579	298	1893	12,534	2,909
1882	386	86	1894	9,027	2,618
1883	1,759	548	1895		2,112
1884	4,626	1,236	1896		3,672
1885	4,598	1,315	1897		4,318
1886	6,808	1,851	1898		3,263
1887	5,421	1,419	1899		8,929
1888	23,919	5,787	1900		10,452
1889	32,818	10,668	1901		4,890
1890	21,055	5,443	1902*		12,234
1891	11,281	2,890			

*Cement, N.E.S., and manufactures of cement, Duty 20 per cent.

TABLE 16.

STRUCTURAL MATER

IMPORTS OF HYDRAULIC

Fiscal Year.
1880
1881
1882
1883
1884
1885
1886
1887
1888
1889
1890
1891
1892
1893
1894
1895
1896
1897
1898
1899
1900
1901
1902 (Cement hydraulic or waterlime)*

*Duty, 12½c. per 100 lbs.

TABLE 17.

STRUCTURAL MATERI

IMPORTS OF PORTLAND C

Fiscal Year.	Barrels.	Value.	Fisca
1880		$ 55,774	1892
1881		45,646	1893
1882		66,579	1894
1883		102,537	1895
1884		102,857	1896
1885		111,521	1897
1886		120,398	
1887	102,750	148,054	1898
1888	122,402	177,158	1899
1889	122,273	179,406	1900
1890	192,322	313,572	1901
1891	183,728	304,648	1902 (P

* Duty, 12½c. per 100 lbs.

Structural Materials.

Production of Roofing Cement.

Table 18.

Structural Materials.

Production of Roofing Cement.

Calendar Year.	Tons.	Value.
1890	1,171	$ 6,502
1891	1,020	4,810
1892	800	12,000
1893	951	5,441
1894	815	3,978
1895	....	3,153
1896	86	430
1897 to 1902 inclusive	Nil.	Nil.

Production of Lime.

Table 19.

Structural Materials.

Annual Production of Lime.

Calendar Year.	Value.	Calendar Year.	Value.
1886	$283,755	1895 estimated	700,000
1887	394,859	1896 "	650,000
1888	339,951	1897 "	650,000
1889	362,848	1898 "	650,000
1890	412,308	1899 "	800,000
1891	251,215	1900 "	800,000
1892	411,270	1901 "	830,000
1893 estimated	900,000	1902 "	892,000
1894 "	900,000		

Exports.

Table 20.

Structural Materials.

Exports of Lime.

Calendar Year.	Value.
1891	$119,853
1892	121,535
1893	86,623
1894	83,670
1895	71,597
1896	70,820
1897	53,177
1898	49,594
1899	73,565
1900	80,852
1901	99,194
1902	116,009

TABLE 21.

STRUCTURAL MATERI

IMPORTS OF LIME

Fiscal Year.	B
1880	
1881	
1882	
1883	
1884	
1885	
1886	
1887	
1888	
1889	
1890	
1891	
1892	
1893	
1894	
1895	
1896	
1897	
1898	
1899	
1900	
1901	
1902 ... ... Duty, 20 p.c.	

TABLE 22.

STRUCTURAL MATERIA

ANNUAL PRODUCTION OF BUILD

Calendar Year.
1886
1887
1888
1889
1890
1891
1892
1893
1894
1895
1896
1897
1898
1899
1900
1901
1902

Structural Materials.

Exports of Bricks.

Table 23.

Structural Materials.

Exports of bricks.

Calendar Year.	M.	Value.
1891	246	$1,163
1892	1,963	12,192
1893	6,073	44,110
1894	1,095	7,405
1895	1,655	8,665
1896	983	5,678
1897	573	2,679
1898	65	442
1899	172	1,351
1900	546	4,528
1901	646	5,189
1902	2,110	12,786

Imports of Building Brick.

Table 24.

Structural Materials.

Imports of Building Brick.

Fiscal Year.	Value.
1880	$ 2,067
1881	4,281
1882	24,572
1883	14,234
1884	20,258
1885	14,632
1886	5,929
1887	2,440
1888	20,720
1889	24,585
1890	12,500
1891	9,744
1892	5,075
1893	14,108
1894	18,320
1895	4,705
1896	23,189
1897	10,336
1898	6,652
1899	21,306
1900	19,305
1901	20,677
1902 Duty, 20 p.c.	33,802

Imports of paving brick in 1898: Value, $2,337; duty, 20 p.c.
" " 1899: " 23,648; "
" " 1900: " 35,644; "
" " 1901: " 10,414; "
" " 1902: " 16,788; "

TABLE 25.

STRUCTURAL MATERIAL

PRODUCTION OF TERRA COT

Calendar Year.	V
1888	
1889	Not
1890	
1891	
1892	
1893	
1894	
1895	
1896	
1897	
1898	
1899	
1900	
1901	
1902	

TABLE 26.

STRUCTURAL MATERIALS.

PRODUCTION OF SEWER PIPE

Calendar Year.
1888
1889
1890
1891
1892
1893
1894
1895
1896
1897
1898
1899
1900
1901
1902

STRUCTURAL MATERIALS.

Imports of Drain Tiles and Sewer Pipes.

TABLE 27.

STRUCTURAL MATERIALS.

IMPORTS OF DRAIN TILES AND SEWER PIPES.

Fiscal Year.		Value.
1880		$ 33,796
1881		37,368
1882		70,065
1883		70,699
1884		71,755
1885		69,589
1886		57,953
1887		71,203
1888		101,257
1889		83,215
1890		77,434
1891		87,195
1892		59,537
1893		39,001
1894		24,625
1895		21,053
1896		19,296
1897		34,286
1898		29,611
1899		33,898
1900		39,149
1901		56,083
	Duty.	
1902 Drain tile, not glazed	20 %	$ 269
1902 Drain pipes, sewer pipes, chimney linings or vents, chimney tops and inverted blocks, glazed or unglazed	35 %	55,261
Total		$55,530

Production of Pottery.

TABLE 28.

STRUCTURAL MATERIALS.

ANNUAL PRODUCTION OF POTTERY.

Calendar Year.	Value.	Calendar Year.	Value.
1888	$ 27,750	1896	163,427
1889	Not available	1897	129,629
1890	195,242	1898	214,675
1891	258,844	1899	185,000
1892	265,811	1900	200,000
1893	213,186	1901	200,000
1894	162,144	1902	200,000
1895	151,588		

TABLE 29.

STRUCTURAL MATERIAL

IMPORTS OF EARTHENWA

Fiscal Year.	Value.	F
1880	$322,339	1891
1881	439,029	1892
1882	646,734	1893
1883	657,886	1894
1884	544,586	1895
1885	511,853	1896
1886	599,269	1897
1887	750,691	1898
1888	697,082	1899
1889	697,949	1900
1890	695,206	1901

1902	Earthenware and china :—
	Baths, tubs and washstands, of earthenwar cement or clay, or of other material, N.O.
	Brown or coloured earthen and stonewa Rockingham ware
	Decorated, printed or sponged, and all earth N.E.S.
	Demijohns, churns and crocks
	White granite or ironstone ware, C.C. or coloured ware
	China and porcelain ware
	Earthenware tiles
	Manufactures of earthenware, N.E.S.
	Total

TABLE 30.

STRUCTURAL MATERIALS.

EXPORTS OF SAND AND GRA

Calendar Year.
1893
1894
1895
1896
1897
1898
1899
1900
1901
1902

MISCELLANEOUS.

MISCELLANEOUS.

Antimony.

Antimony.—There has been no record of production of antimony ore since 1898. The Dominion Antimony Company, Ltd., Halifax, has been formed to work the Rawdon mines, Hants county, Nova Scotia, but no production was obtained in 1902. These mines were worked to a small extent in 1898 and also in 1891 and previous years.

The statistics of exports of antimony ore, Table 2, presented by the Customs Department show an export of antimony ore for each of the past four years. It is thought, however, that this is a result of wrong classification, the export being probably some manufacture of antimony from imported material.

Production.

TABLE 1.

MISCELLANEOUS.

ANNUAL PRODUCTION OF ANTIMONY ORE.

Calendar Year.	Tons.	Value.
1886	665	$31,490
1887	584	10,860
1888	345	3,696
1889	55	1,100
1890	26½	625
1891	10	60
1892 to 1897	Nil.	Nil.
1898	1,344	20,000

Exports.

TABLE 2.

MISCELLANEOUS.

EXPORTS OF ANTIMONY ORES.

Calendar Year.	Tons.	Value.	Calendar Year.	Tons.	Value.
1880	40	$ 1,948	1889	30	$ 695
1881	34	3,308	1890	38	1,000
1882	323	11,673	1891	3½	60
1883	165	4,200	1892 to 1897	Nil.	Nil.
1884	483	17,875	1898	1,232	15,295
1885	758	36,250	1899	6¾	190
1886	665	31,490	1900	210	3,441
1887	229	9,720	1901	10	1,643
1888	352½	6,894	1902	90	13,658

TABLE 3.

MISCELLANEOUS.

IMPORTS OF ANTIMONY.

Fiscal Year.	Pounds.	Value.	Fiscal Year.
1880.........	42,247	$ 5,903	1891.........
1881...... ...	....	7,060	1892.. .....
1882.........	183,597	15,044	1893. .. ....
1883.........	105,346	10,355	1894.........
1884....	445,600	15,564	1895.........
1885..	82,012	8,182	1896.........
1886..	89,787	6,951	1897.........
1887.........	87,827	7,122	1898.........
1888.........	120,125	12,242	1899.........
1889.........	119,034	11,206	1900...... ..
1890........	117,066	17,439	1901.... ....

		Duty.
1902	Antimony, or regulus of, not ground pulverized or otherwise manufactured.	Free.
	Antimony salts........	"
	Total....	.. ..

Arsenic.—The production of white arsenic in mine was 800 tons, valued at $48,000 compared at $41,676 in 1901, and 303 tons valued at $2 output is all obtained as a by-product in workin pickel ores of the Deloro mine, Hastings county practically the only mine on the continent proc present time. The world's supply of arsenic is England and Germany, the production for the p having varied from 7,000 to 8,000 tons per annu

The imports of arsenic into Canada have varie year, a maximum being reached in 1895 when 5 into the country, valued at $31,932. In 1897 o $8,378 were imported, increasing again to 291 tc in 1899, and falling off in 1902 to 53 tons value was not classed as a separate item in the export year 1902 and previous years, but the exports fo ing December 1902 were 274 tons, valued at $16, the exception of $18 worth, went to the United S the market in the United States for arsenic, the into that country during the year ending June 3

MISCELLANEOUS.

Arsenic.

Production.

	Pounds.	Value.
Arsenic, and sulphate of..................	6,930,578	$264,686
Arsenic and arsenous acid...............	1,412,743	44,181
	8,343,321	308,867

TABLE 4.

MISCELLANEOUS.

ANNUAL PRODUCTION OF ARSENIC.

Calendar Year.	Tons.	Value.
1885..........................	440	$17,600
1886..........................	120	5,460
1887..........................	30	1,200
1888..........................	30	1,200
1889..........................	Nil.	Nil.
1890..........................	25	1,500
1891..........................	20	1,000
1892..........................	Nil.	Nil.
1893..........................	"	"
1894..........................	7	420
1895..........................	Nil.	Nil.
1896..........................	"	"
1897..........................	"	"
1898..........................	"	"
1899..........................	57	4,872
1900..........................	303	22,725
1901..........................	695	41,676
1902..........................	800	48,000

TABLE 5.

MISCELLANEOUS.

Imports.

IMPORTS OF ARSENIC.

Fiscal Year.	Pounds.	Value.	Fiscal Year.	Pounds.	Value.
1880.............	18,197	$ 576	1892.............	302,958	9,365
1881.............	31,417	1,070	1893.............	447,079	12,907
1882.............	138,920	3,962	1894.............	292,505	10,018
1883.............	51,953	1,812	1895.............	1,115,697	31,932
1884.............	19,337	773	1896.............	664,854	27,523
1885.............	49,080	1,566	1897.............	152,275	8,378
1886.............	30,181	961	1898.............	291,967	14,270
1887.............	32,436	1,116	1899.............	582,383	24,203
1888.............	27,510	1,016	1900.............	230,730	11,035
1889.............	69,269	2,434	1901.............	159,263	8,361
1890.............	138,509	4,474	1902...Duty free.	106,857	6,004
1891.............	115,248	4,027			

TABLE 6.

MISCELLANEOUS.

IMPORTS OF CHALK.

Fiscal Year.	Value.	Fiscal Year.
1880..	$2,117	1892.........
1881......	2,768	1893.........
1882...........	2,882	1894........
1883..	5,067	1895.... .. .
1884...........	2,589	1896.........
1885.......	8,003	1897.. . .. .
1886.....	6,583	1898.........
1887..	5,635	1899.. .... ..
1888...........	5,865	1900.. ... ..
1889...........	5,336	1901.........
1890...........	7,221	1902*.....
1891..	8,193	

* Chalk prepared. Duty, 20 p. c

TABLE 7.

MISCELLANEOUS.

IMPORTS OF WHITING.

Fiscal Year.	Cwt.	Value.	Fiscal Year.
1880.........	84,115	$26,092	1892.........
1881.........	47,480	16,637	1893.........
1882.........	36,270	16,318	1894....... .
1883.........	76,012	29,334	1895.........
1884.........	76,268	28,230	1896.........
1885...	67,441	23,492	1897.........
1886.........	65,124	25,533	1898.........
1887.	47,246	15,191	1899.........
1888.........	76,619	20,508	1900.........
1889.........	84,658	22,735	1901.........
1890.........	96,243	27,471	1902*...... .
1891.	84,679	27,504	

*Whiting or whitening, gilders whiting, and Paris

Felspar.—Felspar was mined in Canada in 1! Felspar Mining Company at their mine in Bedforc county, Ont. The total production was 7,576 tc compared with 5,350 tons valued at $10,700 pro crease being 2,226 tons or over 41 per cent.

MISCELLANEOUS.

Production of Feldspar.

TABLE 8.

MISCELLANEOUS.

PRODUCTION OF FELDSPAR.

Calendar Year.	Tons.	Value.
1890	700	$3,500
1891	685	3,425
1892	175	525
1893	575	4,525
1894	Nil.	Nil.
1895	....	*2,545
1896	972	*2,583
1897	1,400	3,290
1898	2,500	6,250
1899	3,000	6,000
1900	318	1,112
1901	5,350	10,700
1902	7,576	15,152

* Exports.

Fire-clay.

Fire-clay.—Returns of fire-clay production were received from British Columbia, Nova Scotia and New Brunswick, the importance of the value from each province being in the order named. Practically the total output is obtained in connection with the mining of coal from thin beds usually underlying the coal seams, and the material is mostly used locally in the construction and repairs of coke ovens and in connection with metallurgical operations.

Production.

TABLE 9.

MISCELLANEOUS.

PRODUCTION OF FIRE-CLAY.

Calendar Year.	Tons.	Value.
1889	400	$4,800
1890	Nil.	Nil.
1891	250	750
1892	1,991	4,467
1893	540	700
1894	539	2,167
1895	1,329	3,492
1896	842	1,805
1897	2,118	5,759
1898	670	1,680
1899	599	1,295
1900	1,245	4,130
1901	3,979	5,920
1902	2,741	4,283

Mercury.—There has been no output o
small output for the years 1895, 1896 and
mine in the vicinity of Kamloops lake, B.

"On the properties owned by the Hard
pany considerable work has been done
tunnels were driven as follows :—No. 1 tu
234 feet; No. 3 tunnel, 230 feet; No. 4 t
100 feet; total 1,066 feet; and about $1,
offices, etc. Low grade ore has been enco
in the open cuts on the top of the hill ore
per cent in quicksilver has been found. I
16 men have been employed. It is the i
prosecute development work and possibly
during the ensuing year.

"The Copper Creek Cinnabar Mining C
the necessary assessment work on its prope
are awaiting the results of certain tests of

"The Toonkwa cinnabar claim, south of
developed, and shows up a fine body of or
to exploit on a considerable scale during th

"As there is a good demand for quicksilv
it is hoped that the development will be
should the expectations be fulfilled, the out
promising." (Report of the Minister of Mi

TABLE 10.

MISCELLANEOUS.

PRODUCTION OF MERC

Calendar Year.	Flask (76½ lbs.)
1895	71
1896	58
1897	9

MISCELLANEOUS.

Imports of Mercury.

TABLE 11.

MISCELLANEOUS.

IMPORTS OF MERCURY.

Fiscal Year.	Pounds.	Value.
1882	2,443	$ 965
1883	7,410	2,991
1884	5,848	2,441
1885	14,490	4,781
1886	13,316	7,142
1887	18,409	10,618
1888	27,951	14,943
1889	22,931	11,844
1890	15,912	7,677
1891	29,775	20,223
1892	30,936	15,038
1893	50,711	22,998
1894	36,914	14,483
1895	63,732	25,703
1896	77,869	32,343
1897	76,058	33,534
1898	59,759	36,425
1899	103,017	51,695
1900	85,342	51,987
1901	140,610	94.564
1902........Duty free	97,283	56,615

Molybdenite.

Molybdenite.—A shipment of four tons of molybdenite was made from Coboconk station on the Midland branch of the Grand Trunk railway, according to a statement of railway shipments kindly furnished by freight traffic manager of the above railway. This production is of special interest as although occurrences of this mineral are fairly numerous in the eastern part of Ontario and adjacent portions of Quebec, some difficulty seems to have been experienced in the past in finding deposits of sufficient extent to be of economic importance.

Moulding Sand.

Moulding Sand.—The figures given in Table 12 are derived from returns of railways shipments and do not therefore, nearly represent the total production. Deposits of sands answering the requirements of moulding sand are known to occur in almost every province, and in many cases are worked for the local wants. Of those it is almost impossible to keep record or to obtain returns of output from the producers. The greater proportion of the above railway shipments is derived from deposits in the Ontario peninsula, and is exported to the United States.

TABLE 12.

MISCELLANEOUS.

PRODUCTION OF MOULDING SANI

Calendar Year.	Tons.
1887	160
1888	169
1889	170
1890	320
1891	230
1892	345
1893	4,370
1894	6,214
1895	6,765
1896	5,739
1897	5,485
1898	10,572
1899	13,724
1900	6,181
1901	14,705
1902	13,352

TABLE 13.

MISCELLANEOUS.

ANNUAL PRODUCTION OF QUARTZ.

Calendar Year.	Tons.	V
1890	200	$
1891	...	...
1892	...	...
1893	100	
1894	...	...
1895	...	...
1896	10	
1897	...	...
1898	284	
1899	600	
1900	...	...
1901	...	...
1902	...	...

MISCELLANEOUS.

Imports of Silex.

TABLE 14

MISCELLANEOUS.

IMPORTS OF "SILEX"—CRYSTALLIZED QUARTZ.

Fiscal Year.	Cwt.	Value.
1880	5,252	$ 2,290
1881	3.251	1,659
1882	3,283	1,678
1883	3,543	2,058
1884	3,259	1,709
1885	3,527	1,443
1886	2,520	1,313
1887	14,533	5,073
1888	4,808	2,385
1889	5,130	1,211
1890	1,768	2,617
1891	3,674	1,929
1892	1,429	1,244
1893	2,447	1,301
1894	2,451	1,521
1895	2,882	1,881
1896	3,289	2,174
1897	2,564	3,415
1898	3,104	2,773
1899	3,951	2,595
1900	4,021	2,876
1901	3,562	2,106
1902 .... Duty free.	4,388	3,858

Soapstone.

Soapstone.—No statistics of production of soapstone have been received for the past two years. In previous years small quantities were mined and used chiefly in the manufacture of roofing cement.

Production.

TABLE 15.

MISCELLANEOUS.

ANNUAL PRODUCTION OF SOAPSTONE.

Calendar Year.	Tons.	Value.	Calendar Year.	Tons.	Value.
1886	50	$ 400	1895	475	2,138
1887	100	800	1896	410	1,230
1888	140	280	1897	157	350
1889	195	1,170	1898	405	1,000
1890	917	1,239	1899	450	1,960
1891	Nil	Nil	1900	420	1,365
1892	1,374	6,240	1901	....	....
1893	717	1,920	1902	....	....
1894	916	1,640			

Tin.—No ores of tin are known to occ
report of its occurrence in the Cariboo distri
mentioned by the provincial Mineralogist as

"This department has recently received sa
of a mine in the Cariboo district, and on ex
were found to contain tin in very distinct m
occurrence of tin in the metallic state is
doubt is felt as to the good faith of the senc
covery will require to be further investigatec

The importance of Canadian trade in tin a
be gathered from the accompanying table of

TABLE 16.

MISCELLANEOUS.

IMPORTS OF TIN AND TINW

Fiscal Year.	Value.	Fis
1880	$ 281,880	1891
1881	413,924	1892
1882	790,285	1893
1883	1,274,150	1894
1884	1,018,493	1895
1885	1,060,883	1896
1886	1,117,368	1897
1887	1,187,312	1898
1888	1,164,273	1899
1889	1,243,794	1900
1890	1,289,756	1901

1902	Tin crystals
	Tin in blocks, pigs and bars
	Tin plates and sheets
	Tin foil
	Tin strip waste
	Tin and manufactures of:—
	Tin plate in sheets, decorated
	Tinware, plain, japanned, or lithographed ar all manufactures of tin, N.E.S.
	Total

Tripolite.—Shipments of tripolite in 1902, a
valued at $16,470. This is mined at Bass river
and St. Anns, Victoria county, Nova Scotia,
United States. The operators are, The Premi

*Report of the Minister of Mines, British Columbia

MISCELLANEOUS.

Tripolite.

New York, operating under lease the property at St. Anns owned by the Victoria Tripolite Company, of North Sydney, Cape Breton.

The Fossil Flour Company, New York, operating at Bass river lake.

It is the custom of the Fossil Flour Company to operate their plant at Bass river every second season only, and usually only a portion of the product is shipped during the year of operation, the shipments being continued during the year following.

Production.

TABLE 17.

MISCELLANEOUS.

PRODUCTION OF TRIPOLITE.

Calendar Year.	Tons.	Value.
		$
1896	664	9,960
1897	15	150
1898	1,017	16,660
1899	1,000	15,000
1900	336	1,950
1901	850	15,300
1902	1,052	16,470

INDEX.—V

(NEW SER

NOTE—In this volume there are two part 'A's: the se

Received from the Geolo
of Canada the undermention
tions :

Date

Address

Signature

GEOLOGICAL SURVEY OF CANADA,

Ottawa,...*190*......

It is requested that publications received from this Department be acknowledged by returning the attached form, duly signed and dated.

Failure to acknowledge the receipt of publications will be looked upon as an indication that they are not desired.

Exchanges, for the Library of the Department are respectfully solicited,

The Librarian,
Geological Survey,
Ottawa,
Canada.